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10th ICEC World Congress

The Cost Engineering, Quantity Surveying and Project Management World Congress is promoted by the Brazilian Institute of Cost Engineering (IBEC), in association with the International Cost Engineering Council (ICEC). In order to promote the exchange of information and science costs worldwide. The event is being held in the city of Rio de Janeiro at Windsor Barra Hotel, and happens between 09 and 12 of October, 2016. The Congress addresses issues of considerable importance for Cost Engineering and Project Management Professionals.

The event takes place in Brazil for the first time and presents over two hundred scientific works by professionals from around the world. These articles are open for reading in this journal and their unauthorized reproduction is forbidden.

The Cost Engineering, Quantity Surveying and Project Management 2016 World Congress, hosted in the city of Rio de Janeiro, approaches subjects of major relevance to Costs Engineering on both national and international levels, and also to Project Management, among others. The Congress provides privileged exchange with other countries through ICEC Council Meeting 09 and 12 of October, 2016. This will grant benefits to the entire community.

Rio de Janeiro has its natural beauty and its hospitable, friendly people. In addition, it has been selected to host major worldly events such as the 2014 World Cup and the 2016 Olympics. These events, which were a great success, left a very valuable legacy to the Marvelous City, with its structural renovations, public transportation improvements and the revitalization of urban spaces such as the port area, and that will last for many years to come.

The investments made in the city for these events will only contribute for us to have the necessary infrastructure which, added to the Institute's experience in organizing congresses, seminars and lectures, shall guarantee excellence to the Cost Engineering World Congress of 2016. In fact this Congress will leave a very precious legacy to IBEC, to the city of Rio de Janeiro and consequently to Brazil, to Latin America and to the world, in what concerns the dissemination of the science of costs and project management.

IBEC believes in the importance of cross-border exchange and debate and improvement of technique and technology, of concepts and parameters of Cost Engineering, believing in a multidisciplinary science, integrating companies and professionals acting in the sector, as well as public companies, unions, class entities and students, through lectures, seminars and debates on current, controversial issues.

In cooperation with ICEC (International Cost Engineering Council) we aim to increase the general knowledge of the profession, establishing the importance of committed study on the science of costs nationally and globally.

Holding the first Cost Engineering, Quantity Surveying, Project Management World Congress in South America, in the intent of encompassing more nations from our continent into taking part on the issues of Cost Engineering in a worldly context is a responsibility we take very seriously and accept with great honor.
Finally the biggest event about Cost Engineering, Quantity Surveying and Project Management in the world is happening in Latin America. This is very pleasing and rewarding, given how hard we have been working to attend this end. Four years ago this long-lasting dream was granted, during the 8th ICEC World Congress in Durban (South Africa), and since then we have endeavored with great expectation. We are exultant with this victory and grateful to ICEC for the trust put in our work for the past 35 years.

This conference shall raise great significance to the South American Continent, and also to the world as a whole, creating opportunity of access to information about the profession, in means to disseminate the culture of cost engineering and project management.

In our view this congress will work to transform Cost Engineering from abstract art to what it represents in terms of technique - a science, that is. We always stress the value of a qualified cost engineering professional and we insist on the imperiousness of his certification in the Market, as to eradicate any type of amateur work on the field. The imperativeness in private enterprises, companies and the public body is something we dwell on in lectures and forums every year. Today our country requires fair prices - prices that compensate the specialist and at the same time don't generate negative implications to the government. In this scenario the necessity arose to IBEC of transforming itself, and moving onto investing in academic activities.

Through the Cost Engineering graduate program IBEC proceeded successfully, for over 15 years, with the professionalization of this field, in spite of the absence of this discipline in engineering graduation courses at universities. Our training courses have been proven to be for many professionals an inexhaustible source of knowledge. Moreover, we promote scientific works, presentations and video media on Cost Engineering and Project Management at IBEC's official website.

Another historic landmark to IBEC was the acceptance from ICEC to our Professional Certification Program, IBEC Certificador, recognized internationally. According to Professor José Chacon de Assis, “it is very satisfying to see the results of years of exertion and hard work alongside ICEC to create the international certificates for the professionals”.

After all this I would like to give my warm welcome to everyone that have had the opportunity to join us in such significant moment in the history of the cost engineer and to thank all those who have walked with us towards this congress, which is already proving to be the greatest of all times.

Peace and All Good!

Paulo Roberto Vilela Dias
President of IBEC
Welcome to the 10th International Cost Engineering (ICEC) World Congress, hosted by Instituto Brasileiro de Engenharia de Custos (IBEC).

In advance, I would like to thank IBEC, especially Paulo Dias and his entire board of directors, for their considerable effort in organizing this most excellent congress. The passion and energy of the Brazilians is well noted, and contributes greatly to the success and happiness of the event. I would also like to thank our professional institution members and cooperative associations, the Royal Institution of Surveyors (RICS), AACE International, and the International Project Management Association (IPMA), for partnering with us for this year’s congress.

We would like to extend a special welcome to the CICH (Honduras) and PIQS (Philippines), the newest members of ICEC, and our eminent guests, including the presidents of professional institutions from around the world.

This year’s conference venue is very exciting. Rio de Janeiro is always a joy to visit, especially now in this Olympic year. The location at Barra is unparalleled, with an atmosphere that embodies the conference and the soul of ICEC itself – a bold master plan, combined with respect for history and space for relaxation.

The technical programme and keynote speeches represent the best our profession has to offer, pairing practitioner insight with leading academic research. Panel discussions bring together leaders in the field from around the world, which will no doubt inspire spirited discourse. I personally look forward to attending the technical sessions (and asking a few challenging questions).

Please join us for what is certain to be a very memorable week in Rio, with colleagues, peers, and new and old friends.
The 2016 ICEC World Congress marks the 40th anniversary of the establishment of the International Cost Engineering Council (ICEC). ICEC was founded in 1976 and is a not for profit organisation that promotes cooperation between national and multinational Cost Engineering, Project Controls, Quantity Surveying, and Project Management associations around the globe. It is an umbrella organisation that brings these associations together from around the world to network, share information and bodies of knowledge, raise professional standards, and provide a unified identity for the profession. The key mission of ICEC is to help provide a global identity for the profession and improve professional standards across the globe by bringing cost management associations together to network, share information and knowledge, and to collaborate on professional initiatives for mutual benefit. ICEC does not compete with anyone or any association. Instead ICEC has a focus on supporting associations and bringing them together for the good of the profession.

The past 40 years has seen a tremendous growth in the development and recognition of the profession around the world. ICEC started out with four founding member associations and has now grown to over 40 member associations. The founding members were the AACE International, the UK Association of Cost Engineers (ACostE), the Dutch Association of Cost Engineers (DACE), and the Mexican Society of Engineering Economics, Financing & Costs (SMIEFC).

The ICEC World Congress organisers, the Brazilian Institute of Cost Engineering (IBEC), have been a member of ICEC for over 35 years (having joined ICEC in 1981) and have been instrumental in the development of the profession not only in Brazil but throughout South/Central America where the profession continues to build at a remarkable rate. IBEC has paved a significant course for the profession through the development of their cost engineering certification program tailored to suit not only Brazil but also the South, Central, and Latin American regions with translations in both Portuguese and Spanish. Recognition of the profession has been furthered by the establishment of the annual Brazil National Cost Engineering Day by government legal statute, enabling promotion of the profession throughout the region. IBEC continue to meet and collaborate with engineering associations from throughout the region, including: Argentina, Aruba, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Guatemala, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, Puerto Rico, Uruguay, Venezuela and other countries. The development of the profession in the region is also being strongly supported by the AACE International, IPMA, and the RICS.

I would like to congratulate IBEC, led by IBEC President Mr. Paulo Dias, the IBEC Congress Organising Committees and the Congress Scientific Committee for the tremendous work that they have undertaken to bring the hosting ‘dream’ to a reality. I have seen first-hand the work done by IBEC in organising and marketing the event since they were awarded the hosting rights in 2012 – I have witnessed the perfect blend of professionalism, enthusiasm and passion! Over 100 papers have been accepted for the congress and a number of high profile speakers organised. It promises to be one of the most well attended and successful ICEC congresses on record.

And, of course, it is being held in the most spectacular city in the world – Rio de Janeiro!
It is my pleasure to join IBEC executive and the organizing committee in welcoming you to the 10th ICEC World Congress in Rio, Brazil.

The ICEC World Congress is a unique platform in bringing together prominent cost engineers, quantity surveyors and project managers from all over the world for the exchange and sharing of the latest experiences of the practices. I encourage you to make the best use of this opportunity to network and share your knowledge with your peers.

The host IBEC, have spent a lot of effort in preparing for the event and they have put together an enlightening, filling and entertaining programme for all the participants.

I wish to express my sincere thanks to IBEC and the organizing committee for their hard work and wish the congress every success and that all of you have an enjoyable experience in Rio.

TT Cheung
ICEC Senior Vice Chair
The dream has come true, welcome.

In July 2014 in Durban, former President of ICEC, Murtala Oladapo, from Nigeria, said in the World Council Meeting, right after the exhibition we conducted: “Let’s all go to Rio de Janeiro/Brazil to have the 10th ICEC World Congress, the first one in South America.”. Following this statement the response was almost in unison. Simultaneously manifesting in favor, among others, there were Carsten Wredstrom, ICEC’s future President, and Peter Smith, ICEC’s Secretary General. The Council approved by acclamation.

The following November (2014) already, the Congress was launched in Rio de Janeiro in a big event and the search for the first partnerships began, along with the relentless media outreach work in Brazil and abroad. From then on there was constant attendance to countless congresses, courses and lectures all around Latin America and even in Europe, promoting the event, which includes all possible communication resources, in order to fulfill our mission.

In Brazil, since then, the BDI and Work Costs Forums were being held throughout the country in three cycles, for three and a half years, and the IBEC anniversary parties alongside Cost Engineer Day celebrations emphatically exploited the promotion of the “10th ICEC 2016 World Congress”. We have been present in events held by public and private companies numerous times in all corners of the country, especially the ones conducted by system CONFEA - Conselho Federal de Engenharia e Agronomia (Federal Council of Engineering and Agronomy), CREA - Conselhos Regionais de Engenharia e Agronomia (Regional Councils of Engineering and Agronomy)/MUTUA- Caixa de Assistência dos Profissionais dos CREA (CREA Professionals Insurance Fund).

In spite of the political, social and economic crisis endured in Brazil, we have done our utmost to offer the professionals of Cost Engineering and Project Management an experience interchange opportunity with what is most modern in the world today, and that which is certainly going to be of great value for all: there has been 208 abstracts, 98 drafts and 75 final papers by the International Scientific Committee.

Paulo Dias, that dream we dreamt together has just become reality for being much more than simply ours, congratulations!

I wish us all a fruitful congress!

José Chacon de Assis
Vice President of IBEC
Congress Director
It is definitely a special opportunity to participate in the 10th International Congress of the ICEC in Brazil. Certainly the themes represent a great relevance, based on about 300 technical papers submitted to the Scientific Committee.

Thanks to all authors who submitted their papers and the members of the scientific committee, which included the participation of professional reviewers from different countries, leading to a selection of the best papers for presentation during the event.

We will have a unique opportunity to exchange experiences, develop and strengthen relationships with the international community of Cost Engineering, Quantity Surveyor and Project Management Engineering.
PREVIOUS CONGRESSES

1971 – Montreal, Quebec (Canada)
1972 – Ciudad de Mexico (Mexico)
1974 – London (United Kingdom)
1976 – Boston (USA)
1978 – Utrecht (Netherlands)
1980 – Ciudad de Mexico (Mexico)
1982 – London, England (United Kingdom)
1986 – Montreal, Quebec (Canada)
1986 – Oslo (Norway)
1988 – New York City (USA)
1990 – Paris (France)
1992 – Orlando, Florida (USA)
1994 – London, England (United Kingdom)
1996 – Guadalajara (Mexico)
1998 – Rotterdam (Netherlands)
2000 – Calgary (Canada)
2002 – Melbourne (Australia)
2004 – Cape Town (South Africa)
2006 – Ljubljana (Slovenia)
2008 – Toronto, Ontario (Canada)
2010 – Singapore (Malaysia)
2012 – Durban (South Africa)
2014 – Milan (Italy)
2016 – Rio de Janeiro (Brazil)
The Brazilian Institute of Cost Engineering (IBEC) is a non-political and non-profit organization that aims to promote the techniques and technologies of cost engineering as a multi-disciplinary science, integrating companies and professionals from all sectors. IBEC also holds meetings, lectures, technical meetings, courses, seminars, conferences, and it publishes materials to help cost engineering professionals. Working in partnership with international institutes is also part of IBEC’s goal to help the cost engineering area develop worldwide.

The Brazilian Institute of Cost Engineering was founded on May 27, 1980. It was previously the Brazilian section of the American Association of Cost Engineers (AACE), present in Brazil since 1978 to meet the needs of the main engineering companies and their professionals.

IBEC’s headquarter is located in Rio de Janeiro and it has 17 regional offices: Rio de Janeiro / RJ, São Paulo / SP, São José dos Campos / SP, Campinas / SP, Belo Horizonte / MG, Vitória / ES, João Pessoa / PA, Aracaju / SE, Cuiabá / MT, Fortaleza / CE, Recife / PE, Brasília / DF, Salvador / BA, Curitiba / PR, Foz do Iguaçu-PR, Porto Alegre / RS and Joinville / SC.

The 10th ICEC Cost Engineering and Project Management World Congress is being held in South America for the first time. IBEC feels honored to host the event and to collaborate once more for the promotion of Cost Engineering. Through its Chairman - Engineer Paulo Roberto Vilela Dias, who is also ICEC Officer for the Americas, the Institute has carried out a worldwide networking process which enables collaboration with institutions from the whole spectrum of Engineering in numerous nations in the world. These include:

- Realization
- IBEC
- www.ibec.org.br
- The Brazilian Institute of Cost Engineering (IBEC) is a non-political and non-profit organization that aims to promote the techniques and technologies of cost engineering as a multi-disciplinary science, integrating companies and professionals from all sectors. IBEC also holds meetings, lectures, technical meetings, courses, seminars, conferences, and it publishes materials to help cost engineering professionals. Working in partnership with international institutes is also part of IBEC’s goal to help the cost engineering area develop worldwide.

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- U.Porto
- FEUP (Faculty of Engineering of the University of Porto), Portugal
- Consejo Profesional de Ingeniería Química (Professional Council of Chemical Engineering), Argentina
- Colegio de Ingenieros Civiles de Honduras (College of Civil Engineers of Honduras), Honduras
- Società Dante Alighieri (Society Dante Alighieri), Italy
- Global Partners Bayern e.V.
- Instituto Águas da Terra (Institute Waters of the Earth), ONU
- Sociedad Colombiana de Ingenieros (Society of Engineers of Colombia), Colombia
- Sociedad de Ingenieros de Bolivia (Society of Engineers of Bolivia), Bolivia
- Ordem dos Engenheiros de Cabo Verde (Order of Engineers of Cabo Verde), Cabo Verde

ICEC
www.icoste.org

The Cost Engineering is organized worldwide around ICEC (International Cost Engineering Council), which is currently present in more than forty (40) countries.

ICEC is the world organization that brings together national associations Cost Engineering, legitimate representatives of various countries.

A non-political and non-profit organization, founded in 1976, aiming to promote cooperation between national and multinational organizations aimed at Cost Engineering and Project Management.

Major objectives of ICEC

1. To encourage, promote, and advance the sciences and arts of cost engineering, quantity surveying, and project management for the public good, worldwide;
2. To coordinate and sponsor International Cost Engineering, Quantity Surveying and Project Management Congresses (on a worldwide scale);
3. To coordinate and sponsor International Cost Engineering, Quantity Surveying and Project Management Symposia (on a continental scale);
4. To encourage cost engineers, quantity surveyors and project managers in countries where no formal association or organization exists to form a group with objectives compatible with those of ICEC and its members;
5. To participate in international events related to the practice of cost engineering, quantity surveying and project management sponsored by governmental and private organizations, national or international, whether members of ICEC or not, provided that these events are in keeping with the objectives of ICEC;
6. To further the study of cost engineering, quantity surveying and project management problems of worldwide or multinational character; and
7. To encourage the development of professional certification programs in cost engineering, quantity surveying and project management.
Our international network

ICEC is a worldwide confederation of cost engineering, quantity surveying and project management societies which acts to promote worldwide exchange of cost engineering and project management information and experiences.

ICEC is divided geographically into regions to encourage communication and to foster joint congresses, symposia, and forums on a continental or regional scale. The Regions are:

- Region 1 North and South America;
- Region 2 Europe and the Near East;
- Region 3 Africa; and
- Region 4 Asia Pacific.

A Region Director is appointed to oversee ICEC’s activities within each region.

Through our regional structure, and as a organisation as a whole, ICEC endeavours to:

- Encourage the conduct of regional and worldwide congresses, meetings, forums, and seminars;
- Promote co-operative research and technical activities among the member societies;
- Promote development of standards for accreditation and recognition of cost engineering, quantity surveying and project management certification programs offered by the member societies;
- Encourage national and international networking among the members of all ICEC societies within the regions and worldwide; and
- Develop international standards for terminology in cost engineering, quantity surveying and project management.
Co-Realization

IPMA Brasil – International Project Management Association Brasil
www.ipmabrasil.org

AACE International – Association for the Advancement of Cost Engineering
www.aacei.org

UERJ – Universidade Estadual do Rio de Janeiro (Rio de Janeiro State University)
www.uerj.br

RICS – Royal Institute of Chatered Surveyors
www.rics.org
In Brazil, the 10th ICEC World Congress is sponsored and supported by various institutions of major relevance for the country and for the world as well. They are:

**Sponsorship**

- **Itaipu Binacional (Itaipu Binational)**
  - [www.itaipu.gov.br](http://www.itaipu.gov.br)

- **Crea-RJ (Regional Council of Engineering and Agronomy from Rio de Janeiro)**
  - [www.crea-rj.org.br](http://www.crea-rj.org.br)

- **MÚTUA - Caixa de Assistência dos Profissionais do CREA (Insurance Fund for Professionals of CREA)**
  - [www.mutua.com.br](http://www.mutua.com.br)

- **SENGE-RJ - Sindicato dos Engenheiros no Estado do Rio de Janeiro (Engineering Union of the State of Rio de Janeiro)**
  - [www.sengerj.org.br](http://www.sengerj.org.br)

- **FISENGE - Federação Interestadual de Sindicatos de Engenheiros (Interstate Federation of Engineering Unions)**
  - [www.fisenge.org.br](http://www.fisenge.org.br)

- **Systech International**
  - [www.systech-int.com](http://www.systech-int.com)

- **Bocater**
  - [www.bocater.com.br](http://www.bocater.com.br)
Support

Confea - Conselho Federal de Engenharia e Agronomia
(Federal Council of Engineering and Agronomy)
www.confea.org.br

CREA - Conselhos Regionais de Engenharia e Agronomia
(Regional Councils of Engineering and Agronomy)
www.confea.org.br

MÚTUA - Caixa de Assistência dos Profissionais do CREA
(Insurance Fund for Professionals of CREA)
www.mutua.com.br

Prefeitura do Rio de Janeiro - Secretaria de Obras
(Rio de Janeiro City Hall - Secretariat of Constructions)
www.rio.rj.gov.br

ABC - Associação Brasileira de Custos (Brazilian Association of Costs)
www.abcustos.org.br

Feup - Faculdade de Engenharia
(Faculty of Engineering of the University of Porto)
sigarra.up.pt/feup

NPPG - UFRJ Núcleo de Pesquisas em Planejamento e Gestão
(Federal University of Rio de Janeiro - Planning and Management Research Core)
nppg.org.br/DisciplinasOnline/login/index.php

Faculdade Mackenzie Rio (Mackenzie Faculty of Rio)
www.mackenzie-rio.com.br/home.html
Instituto IDD (IDD Institute)
www.idd.com.br

Universidade Santa Úrsula (University Santa Úrsula)
www.usu.br

INPG - Instituto Nacional de Pós-Graduação (National Institute of Postgraduate)
www.inpg.edu.br

PINI
www.pini.com.br

IE - Instituto de Engenharia (Engineering Institute)
www.institutodeengenharia.org.br

Instituto de Engenharia do Paraná (Engineering Institute of Paraná)
www.iep.org.br

Clube de Engenharia (Engineering Club)
portalclubedeengenharia.org.br

FEBRAE - Federação Brasileira de Associações de Engenheiros, Agrônomos e Arquitetos (Brazilian Federation of Engineers, Agronomists and Architects)
www.febrae.org.br
ANE - Academia Nacional de Engenharia (National Engineering Academy)
www.anebrasil.org.br

UPADI - Unión Panamericana de Asociaciones de Ingenieros (Pan-American Union of Engineering Associations)
www.upadi.com

CICH - Colegio de Ingenieros Civiles de Honduras (College of Engineers of Honduras)
www.cichorg.org

S.I.B. - Sociedad de Ingenieros de Bolivia Departamental Santa Cruz (Society of Engineers of Bolivia - Departmental of Santa Cruz)
www.sibsc.com

Global Partners Bayern e.V.
www.global-partners-bayern.de

USAL - Universidad del Salvador University of Salvador
www.usal.edu.ar

Consejo Profesional de Ingeniería Química (Professional Council of Chemical Engineering)
www.cpiq.org.co

OECV - Ordem dos Engenheiros de Cabo Verde (Order of Engineers of Cabo Verde)
http://www.oecv.c
ALAIST / ALAEST - Associação Latino Americana de Engenharia de Segurança (Latin American Association of Safety Engineering)
www.alaest.org/home.php

UNAICC - União Nacional de Arquitetos e Ingenieros de la Construcción de Cuba (Cuban National Union of Architects and Engineers of Construction)
www.unaicc.cu

DA - Società Dante Alighiere (Society Dante Alighieri)
ladante.it

Project Builder
www.projectbuilder.com.br

AENFER – Associação de Engenheiros Ferroviários (Railroad Engineers Association)
www.ferrovias.com.br

SBEF - Sociedade Brasileiro de Engenheiros Florestais (Brazilian Society of Forestry Engineers)
www.sbef.org.br

IBRAENG - Instituto Brasileiro de Auditoria de Engenharia (Brazilian Engineering Audition Institute)
www.ibraeng.org

Instituto Águas da Terra (Institute Waters of the Earth)
THEMES 2016

Strategic Projects Decisions and Cost Control in Public Administrations
ROI decisions and selecting strategic projects mark the way of economic development; cost control and reporting are a must for a good and transparent administration.

The New Frontiers of Building Information Modeling (BIM)
The incorporation of cost, schedule and facilities data in BIM practice enables companies to become competitive on an international level.

Global Project, Complex Project, trouble in Difficult Times
Global projects are those more suitable to TCM adoption due to their dimensions, uncertainty, complexity as well as the multiple contractors involved.

Project Management, Portfolios and Programmes
Project Management Methodologies, Programs and Portfolio as standardization of procedures and practices, cost reduction, risk reduction among others.

Cost Management in Projects / Quantity Surveying
The management of changes in costs on projects using tools such as Earned Value Management, analysis of variations in costs using standard cost.

Financial Accountability
Financial accounting as a strategic tool of decision.

Feasibility Analysis
Analysis of viability and feasibility in projects and general developments.

Cost Estimating: Art or Science?
Estimating processes are a traditional topic of TCM.

Project Risk Management & Control
Project risk management is fundamental for anyone involved in the project delivery process; but beyond academic discussions, practical applications are considered very useful in the actual economic context.

Claim & Dispute Resolution
Claim & dispute resolution has been a typical TCM topic, nevertheless it is still an important pillar of TCM practice.
Individual and Corporate Training and Certification
Certification is an important way to qualify individual skill and experience; continuing education is necessary for the future of our profession. These are powerful indicators by which to select reliable candidates for important joint ventures & partnerships.

Teaching and Coaching TCM Practices (Total Cost Management)
ICEC and every local TCM Institution are interested in transferring TCM practices to young people in order to pave the way for the next generation: any contribution on methods and experiences for this transfer of knowledge is well accepted.

Methodologies and Quantitative Methods to Support TCM
Observatory on professional practices and new methodology frontiers.

Teaching & Training Methodologies and Research Experiences
Instruments, tools and metrics developed and / or adapted to facilitate or improve teaching & Training as well as research in project management and cost area.

Contemporary Approaches Costs and Project Management
Studies that incorporate trends in the cost area: logistics costs, quality costs, intercompany costs, intangible costs, environmental costs, transaction costs, costs of complexity etc.

Sustainability and the Environment
Studies and management of environmental costs and sustainability.

Innovative and Creative Practices
Academic studies and case studies with instruments, tools and innovative and creative practices for cost management.

Best Practice and Ethics
Studies and research about best practices and ethics in total cost management.

Information Technology
Studies, research and practice of information technology related to cost management.

Continuing Professional Development
The cost professionals challenge related to new technologies.
Dispute Resolution
Best practices for resolving disputes related to project management.

Cost Management
Use of costing methodologies in the process of planning and control in the strategic management cost.

Auditing Public Construction
Audit of Public Works, best practices, case studies, tools and instruments.

Company Profitability Increase Using TCM
Real-life experiences on TCM application both at project and enterprise level in order to achieve company profitability.

From Project Control to Company Control with TCM Practices
The evolution of TCM from theory to systematic practice applied to projects, programs and portfolios.

Owner / Contractor / Professional Issues
TCM effectiveness is measured by its ability to solve the issues of every actor in the project delivery process.

Programme Risk Sharing
The possibility to share risks among clients and suppliers represents a way to get profitability and balance the risks: advanced techniques and practices (Open Book Cost Estimate, etc.) are needed.

Project Governance
Ensure that the project execution guidelines of Corporate Governance will be applied in project management.

Project Control
Among the projects to be controlled those long term running have particular need to be controlled in a systematic way.

Health Care Projects (a New Field for the Implementation of TCM Practice)
TCM practice is not generally applied to the healthcare sector but the sector itself could increasingly benefit from its use, especially during crisis periods.
SCIENTIFIC COMMITTEE

Fernando José da Rocha Camargo, Brazil - Committee Honorary President
Alan Barltrop, United Kingdom
Aldo Mattos, Brazil
Alec Ray, United Kingdom
Alessandro Margherita, Italy
Alexia A. Nalewaik, USA
Alfredo Biffi, Italy
Alfredo Serpell, Chile
Allen Hamilton, USA
Andrej Kerin, Slovenia
Angelo S. do Valle, Brazil
Antonio Carlos Guidi, Brazil
Alvaro da Cunha Caldeira, Brazil
Carsten Wredstrom, Denmark
Chris Walker, USA
Cláudio Quartaroli, Brazil
Dennis Lenard, USA
Gianluca DiCastri, Italy
José Antonio Rosa, Brazil
José Chacon de Assis, Brazil
Julio Nichioka, Brazil
Kwadwo Osei-Asante, Gana
Marcello Costa, Brazil
Massimiliano Arena, Italy
Morten Fangel, Denmark
Murilo Alambert, Brazil
Murtala Oladapo, Nigeria
Paul Ho, Hong Kong
Paulo Roberto Vilela Dias, Brazil
Peter Cox, Australia
Peter Smith, Australia
Pietro Guedes, Brazil
Raphael Albergarias, Brazil
Ricardo Delarue, Brazil
Ricardo Soares, Brazil
Roberto Mori, Italy
Roberto Vitiello, Brazil
Roger M. Batten, United Kingdom
Ronaldo Miranda Pontes, Brazil
Rubens Cirino, Brazil
Walther Krause, Brazil

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<th>Schedule</th>
<th>ID</th>
<th>Speaker</th>
<th>Paper Title</th>
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<tbody>
<tr>
<td>01:30</td>
<td>23</td>
<td>Mauro Stucchi</td>
<td>Contract and Claim Management (CCM) in Product vs Project Business</td>
</tr>
<tr>
<td>01:50</td>
<td>20</td>
<td>Gianluca di Castri</td>
<td>Semantics in total cost management</td>
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<tr>
<td>02:10</td>
<td>193</td>
<td>Peter Smith</td>
<td>Home Ownership Rates &amp; Affordability – Global Comparisons</td>
</tr>
<tr>
<td>02:30</td>
<td>50</td>
<td>Njeri Wachira-Towey</td>
<td>Use of construction management software by construction firms in Kenya</td>
</tr>
<tr>
<td>02:50</td>
<td>130</td>
<td>Jefferson Guimarães</td>
<td>Success Driven Project Management: Planning and Controlling cost, time, scope &amp; risks with the calculation of success probability trends</td>
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</tbody>
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**Coffee-Break (3:30 - 3:50 pm)**

<table>
<thead>
<tr>
<th>Schedule</th>
<th>ID</th>
<th>Speaker</th>
<th>Paper Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>03:50</td>
<td>171</td>
<td>João Carlos Papadopoulos de Souza</td>
<td>META-INTEGRATION - A methodology for integrating projects from commissioning stage</td>
</tr>
<tr>
<td>04:20</td>
<td>34</td>
<td>Gianluca di Castri</td>
<td>An engineering approach to economic development</td>
</tr>
<tr>
<td>04:40</td>
<td>356</td>
<td>Antonio Gordilho</td>
<td>Operational Transfer of Engineering Projects</td>
</tr>
<tr>
<td>05:00</td>
<td>33</td>
<td>Ricardo Delarue</td>
<td>Using EVM as a tool for evaluating the trend of Time &amp; Cost in Projects</td>
</tr>
<tr>
<td>05:20</td>
<td>122</td>
<td>Guilherme Motta</td>
<td>Agile Governance Model in Project Portfolio</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Schedule</th>
<th>ID</th>
<th>Speaker</th>
<th>Paper Title</th>
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</thead>
<tbody>
<tr>
<td>01:30</td>
<td>454</td>
<td>Guadalupe Araújo Yanguas</td>
<td>Cost impact of the final disposal of construction residue in urbanization of slums by the Housing Department of the City of São Paulo</td>
</tr>
<tr>
<td>01:50</td>
<td>364</td>
<td>Marcos Fernando Haffner</td>
<td>WEBPROJECT - Customization project management software</td>
</tr>
<tr>
<td>02:10</td>
<td>346</td>
<td>Juan Peres de Oliveira; João Felipe Mariano; Matheus Kock; Thiago Luis Rodrigues; Bruno Thiago Tomio</td>
<td>Cost reduction in the application of shipping containers in construction</td>
</tr>
<tr>
<td>02:30</td>
<td>100</td>
<td>André Uryn; Thiago Araújo</td>
<td>Critical analysis of the position taken by the Brazilian Federal Audit Court regarding modification of public works contracts during their term</td>
</tr>
<tr>
<td>02:50</td>
<td>52</td>
<td>Ronaldo Pontes; Carlos Henrique da Mota; Lionardo Elias Soares; Bruno Marques Antunes</td>
<td>Total productive maintenance (tpm) on quality cost management - case study in food industry</td>
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<tr>
<td>03:10</td>
<td>256</td>
<td>Gunter Nothling</td>
<td>Contingencies for an Enterprise</td>
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**Coffee-Break (3:30 - 3:50 pm)**

<table>
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<tr>
<th>Schedule</th>
<th>ID</th>
<th>Speaker</th>
<th>Paper Title</th>
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</thead>
<tbody>
<tr>
<td>03:50</td>
<td>231</td>
<td>Silvio Mourão</td>
<td>The characteristics of infrastructure construction cost estimating in Brazil</td>
</tr>
<tr>
<td>04:20</td>
<td>270</td>
<td>Helber Macedo; Ferreira C.T; Fonseca, F.C.R; Braga, C.E.M.F</td>
<td>Alignment of Contingency Definition Concepts and Estimate Methodology</td>
</tr>
<tr>
<td>04:40</td>
<td>60</td>
<td>Giancarlo Guenzi</td>
<td>Optimization of the investment of a large system/plant, as a balance between reliability, costs and incomes</td>
</tr>
<tr>
<td>05:00</td>
<td>131</td>
<td>Bruno Dias; Martins C.; Ribeiro, J.</td>
<td>Project Management methodology based on applications Lean Office</td>
</tr>
<tr>
<td>05:20</td>
<td>35</td>
<td>Gianluca di Castri</td>
<td>Equitable payment and social inequalities</td>
</tr>
<tr>
<td>05:40</td>
<td>274</td>
<td>James Rotimi; Ramachandra, T.; Windapo, A.O.</td>
<td>An Analysis of Liquidators’ reports for construction companies in New Zealand</td>
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</table>
### Room Segovia 3

<table>
<thead>
<tr>
<th>Schedule</th>
<th>ID</th>
<th>Speaker</th>
<th>Paper Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>01:30</td>
<td>255</td>
<td>Alfredo Serpell; Paula Riquelme</td>
<td>Context factors in the cost estimation of construction projects</td>
</tr>
<tr>
<td>01:50</td>
<td>43</td>
<td>John Livengood</td>
<td>Why Different Delay Methodologies give Different Results</td>
</tr>
<tr>
<td>02:10</td>
<td>48</td>
<td>Peter Smith</td>
<td>Sustainable Retrofitting - Global Strategies &amp; Implementation Issues</td>
</tr>
<tr>
<td>02:30</td>
<td>357</td>
<td>Eduardo Teixeira</td>
<td>Classification and characterization of losses involved in public building work: a case study in the city of Salgueiro / PE, Brazil</td>
</tr>
<tr>
<td>02:50</td>
<td>104</td>
<td>Robson Bernardes Faustino</td>
<td>Costs of public work in Brazil</td>
</tr>
<tr>
<td>03:10</td>
<td>115</td>
<td>Márcio Rocha</td>
<td>Estimation of concrete volume by multiple linear</td>
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**Coffee-Break (3:30 - 3:50 pm)**

<table>
<thead>
<tr>
<th>Schedule</th>
<th>ID</th>
<th>Speaker</th>
<th>Paper Title</th>
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<tbody>
<tr>
<td>03:50</td>
<td>153</td>
<td>Sandra Bahamon; Carlos A. Vargas; Diego Hernandez</td>
<td>An approach to the identification of external factors on the project complexity</td>
</tr>
<tr>
<td>04:20</td>
<td>247</td>
<td>Vania Menezes</td>
<td>The parallel management using concurrent engineering: the case of constructions at nuclear submarine development program.</td>
</tr>
<tr>
<td>04:40</td>
<td>99</td>
<td>Paulo Dias</td>
<td>Cost Engineering and Compliance Price Analysis</td>
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<tr>
<td>05:00</td>
<td>380</td>
<td>David Grubba; Cynthia de Freitas Queiroz; Mateus Aguiar Lima; Caio Freitas Raber; José Leomar Fernandes Júnior</td>
<td>Megaprojects viability studies: a critical analysis</td>
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<tr>
<td>05:20</td>
<td>180</td>
<td>Theonelly Theodozio</td>
<td>Cost evaluating of engineering solution in a public work through parametric estimating</td>
</tr>
<tr>
<td>05:40</td>
<td>26</td>
<td>Martinus Maritz</td>
<td>Defective work claims dilemma: what are the contractual/common law rights of owners and obligations of contractors</td>
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### Room Segovia 4

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<th>Schedule</th>
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<tbody>
<tr>
<td>01:30</td>
<td>15</td>
<td>Alan Muse</td>
<td>Measurement standards: space, cost and technology</td>
</tr>
<tr>
<td>01:50</td>
<td>501</td>
<td>Jennifer Musyimi</td>
<td>Challenging the contracting execution approach for construction projects: - a case of kenya</td>
</tr>
<tr>
<td>02:10</td>
<td>186</td>
<td>Herbet De Jesus Costa Santiliano</td>
<td>Usage of neural network in the analysis of cost structures of organizations</td>
</tr>
<tr>
<td>02:30</td>
<td>203</td>
<td>Marcus Possi</td>
<td>A Bridge Over Tough Waters</td>
</tr>
<tr>
<td>02:50</td>
<td>239</td>
<td>Ernest Kissi</td>
<td>Key economic indicators that influence tender price in the ghanaian building industry</td>
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**Coffee-Break (3:30 - 3:50 pm)**

<table>
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<tr>
<th>Schedule</th>
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<th>Paper Title</th>
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<tbody>
<tr>
<td>03:50</td>
<td>250</td>
<td>José Arnaldo Villamarim Júnior</td>
<td>Analysing technic-economical feasibility of the introduction of photovoltaic-wind power hybrid energy-generating system with conection to the power grid as supply for a cellular transmitter site</td>
</tr>
<tr>
<td>04:20</td>
<td>276</td>
<td>Geórgia Morais Jereissati</td>
<td>Direct costs analysis of superstructure residential building - case study in Fortaleza - Brazil</td>
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<tr>
<td>04:40</td>
<td>176</td>
<td>Giuliano Cunha Coutinho</td>
<td>Prioritization of Project Management Processes - Chain of Tools</td>
</tr>
<tr>
<td>05:00</td>
<td>14</td>
<td>Luqman Oyekunle Oyewobi</td>
<td>Business failures among Small and Medium sized construction companies' in Abuja, Nigeria</td>
</tr>
<tr>
<td>05:20</td>
<td>24</td>
<td>Gabriel Falcini; Tokede, O.O.</td>
<td>Last Planner System – from theory to implementation</td>
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## Room Segovia 1

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<th>Schedule</th>
<th>ID</th>
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<tbody>
<tr>
<td>01:30</td>
<td>32</td>
<td>Dinko Bacun</td>
<td>The Model of Multiple and Parallel Runtime Trend Measurement and Prediction of Schedule Activities as a Function of Project Cost Control</td>
</tr>
<tr>
<td>01:50</td>
<td>129</td>
<td>Joel Valentini Valentini</td>
<td>Methodology for elaboration and analysis of commercial proposals for execution of civil works</td>
</tr>
<tr>
<td>02:10</td>
<td>271</td>
<td>Victor Kraemer Wermelinger Sancho Araujo; Silvino Filho, S.R.P.; Miranda, T. A.</td>
<td>Physical Progress Trend Analysis Based on Earned Schedule Performance - An Owner’s Perspective</td>
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<tr>
<td>02:30</td>
<td>17</td>
<td>Raphael Albergarias; Nikiforos Ioannis Philippis Jr; Eduardo Linhares Qualharini</td>
<td>Post-project Review in Construction: A means to achieving Sustainable Construction</td>
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<tr>
<td>02:50</td>
<td>27</td>
<td>Olubukola Tokede</td>
<td>Evaluating the cost of disruption in retrofit office building projects</td>
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<tr>
<td>03:10</td>
<td>367</td>
<td>Atila Ribas</td>
<td>Performance assessment and cost analysis of a photovoltaic system located in Curitiba - Brazil</td>
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### Coffee-Break (3:30 - 3:50 pm)

<table>
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<tr>
<td>03:50</td>
<td>114</td>
<td>Mauricio Gouvea Silva</td>
<td>Sustainability Risk Management as a key factor on Corporate Projects</td>
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<tr>
<td>04:20</td>
<td>54</td>
<td>Julie Owen</td>
<td>Implementing a Program Management Office at Los Angeles Metro</td>
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<td>04:40</td>
<td>210</td>
<td>Luiz Rubião; Marcelo Chicralla</td>
<td>Impact of ERP Implementation on an Engineering Company</td>
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<tr>
<td>05:00</td>
<td>158</td>
<td>Walther Krause</td>
<td>Project Audit Process and Project Governance to Improve Results</td>
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<tr>
<td>05:20</td>
<td>507</td>
<td>Alexia Nalewaik</td>
<td>A path to project performance</td>
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## Room Segovia 2

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<tr>
<td>01:30</td>
<td>110</td>
<td>Juliana Bevilacqua Jacob</td>
<td>Self-compacting concrete: cost analysis x productivity construction site compared to conventional concrete</td>
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<tr>
<td>01:50</td>
<td>91</td>
<td>Otto Machado Filho; Nelson F. F. Ebecken</td>
<td>Forecasting Engineering Design Project Errors</td>
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<tr>
<td>02:10</td>
<td>225</td>
<td>Lucas Encarnação Silva; Zanon, D.M; Dias, B.</td>
<td>The Cost of Being Green: Case Study of a Certification Methodology</td>
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<tr>
<td>02:30</td>
<td>140</td>
<td>Marcos Rego; Renato Chaves</td>
<td>Project Portfolio Best Practices in Information Technology Projects: A Case Study</td>
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<tr>
<td>02:50</td>
<td>355</td>
<td>Inaiara Barcellos</td>
<td>Comparative Study Budget run on Platform BIM 5D and Conventional Budget based on 2D Autocad design</td>
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<tr>
<td>03:10</td>
<td>493</td>
<td>Maçahico Tisaka</td>
<td>Composition BDI - aspects still controversial of the BDI formula</td>
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### Coffee-Break (3:30 - 3:50 pm)

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<tbody>
<tr>
<td>03:50</td>
<td>41</td>
<td>Rubens de Almeida; Luiz Raymundo Freire</td>
<td>Hamperingness and Contingencies</td>
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<tr>
<td>04:20</td>
<td>126</td>
<td>Marco Aurélio da Silva Máximo; Maria Amélia Mello Galvão; Sylvio Caminho de Farias</td>
<td>Restoration public works: The costs analysis based on Federal Decree 7983/2013</td>
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<tr>
<td>04:40</td>
<td>61</td>
<td>Eduardo Alberto Manjarres Trelles</td>
<td>Stakeholders and the search for appropriate foundations of public policy criteria</td>
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<tr>
<td>05:00</td>
<td>111</td>
<td>Mario Lopes</td>
<td>When overbilling is illegal</td>
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### Room Segovia 3

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<th>ID</th>
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<tr>
<td>01:30</td>
<td>213</td>
<td>Jefferson Guimarães</td>
<td>Fuzzy Logic in Project Risk Management</td>
</tr>
<tr>
<td>01:50</td>
<td>179</td>
<td>Bruno Costa Chaves</td>
<td>Costs analysis of constructions heavy equipment</td>
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<tr>
<td>02:10</td>
<td>75</td>
<td>Thaís Leal Corrêa da Silva</td>
<td>Presentation of practice worksheet to determinate costs of building living areas in construction sites, based on Brazilian standards</td>
</tr>
<tr>
<td>02:30</td>
<td>103</td>
<td>Rafael Travincas</td>
<td>Engineering projects prioritisation using the analysis multicriteria ahp</td>
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<tr>
<td>02:50</td>
<td>116</td>
<td>Danie Hoffman; Bassin, J.G.W</td>
<td>Economics of Green Building – South African stakeholder perspectives</td>
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<tr>
<td>03:10</td>
<td>249</td>
<td>Glauco da Silva; José Renato Góes de Paiva; Adalberto Ermida Franco</td>
<td>Parametric Estimating of Operation Costs of Cranes for Construction</td>
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<td>Coffee-Break (3:30 - 3:50 pm)</td>
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<tr>
<td>03:50</td>
<td>93</td>
<td>Hipolito Sousa; Pedro Meda</td>
<td>Strategic roadmap for construction process integration – Portuguese steps</td>
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<tr>
<td>04:20</td>
<td>28</td>
<td>Lucia Ncalane</td>
<td>Claims and Disputes in the Construction Industry</td>
</tr>
<tr>
<td>04:40</td>
<td>59</td>
<td>Baris Ozkaya; Hatice Çalipinar; Banu Akin</td>
<td>A learning curve investigation: multiple phase</td>
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<tr>
<td>05:00</td>
<td>167</td>
<td>Otavino Silva</td>
<td>The technology of procedural cost engineering for manufacturing companies with neuromanagement fundamentals, from business model generation (canvas), from design thinking and from microeconomy</td>
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<tr>
<td>05:20</td>
<td>115</td>
<td>Miguel Chichorro; Pedro Rocha</td>
<td>Management integrated methodology</td>
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### Room Segovia 4

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<th>Speaker</th>
<th>Paper Title</th>
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</thead>
<tbody>
<tr>
<td>01:50</td>
<td>202</td>
<td>João Carlos Martins</td>
<td>Project Management with Sustainability and Productivity</td>
</tr>
<tr>
<td>02:10</td>
<td>154</td>
<td>Juliana Cariello; Celso Ramos; Edson Marinho; Pietro Guedes; Luiz Rocha</td>
<td>How to Manage Development Projects Efficiently and Effectively to Change the World</td>
</tr>
<tr>
<td>02:30</td>
<td>151</td>
<td>Ronaldo Pontes; Leandro Brito de Souza; Ana Valeria Vargas; Murilo Alambert; Karen Estefan Dutra</td>
<td>Impact in the costs with the absenteeism of a graphics industry</td>
</tr>
<tr>
<td>02:50</td>
<td>94</td>
<td>Edward Van Doorn</td>
<td>Cost Growth and Schedule Slip Analysis - A Private Equity firm’s perspective</td>
</tr>
<tr>
<td>03:10</td>
<td>245</td>
<td>Samuel Barros; Raphael Albergarias; Eduardos Linhares Qualharini</td>
<td>Factors that affect transaction costs in projects in Brazil</td>
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### Coffee-Break (3:30 - 3:50 pm)

<table>
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<tr>
<th>Schedule</th>
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<th>Speaker</th>
<th>Paper Title</th>
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<tbody>
<tr>
<td>03:50</td>
<td>36</td>
<td>Isadora Rodrigues</td>
<td>Comparative Study of the Official Price Tables Applied in the State of Ceará, on the Housing Development Program “Minha Casa Minha Vida”.</td>
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<tr>
<td>04:20</td>
<td>105</td>
<td>Victor Nogueira Lima</td>
<td>Cost analysis of building systems for single-family buildings in Cariri Ceará: conventional masonry and steel frame</td>
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<tr>
<td>04:40</td>
<td>188</td>
<td>Vitor Araujo; Murilo Alambert</td>
<td>EVM on an Engineering Company - Case</td>
</tr>
<tr>
<td>05:00</td>
<td>226</td>
<td>Felipe Schaker; Adriana Santos</td>
<td>Integration of BIM and e-procurement in the Construction Industry: a Systematic Bibliographic Review</td>
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**DETAILED PROGRAMME (General)**

**Sunday, 9th October**

<table>
<thead>
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<th>Event</th>
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<tbody>
<tr>
<td>4-9 P.M.</td>
<td>Registration of Delegates</td>
</tr>
<tr>
<td>8-10 P.M.</td>
<td>Welcome Party (Cocktail)</td>
</tr>
<tr>
<td></td>
<td><strong>Venue:</strong> Terrace Oriente (Windsor Barra Hotel)</td>
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**Monday, 10th October**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>7:30 A.M.</td>
<td>Registration of Delegates</td>
</tr>
<tr>
<td>9 A.M.</td>
<td>Opening Ceremony</td>
</tr>
<tr>
<td>10-10:20 A.M.</td>
<td>Coffee Break (Hall 1st floor)</td>
</tr>
<tr>
<td>10:30 - 12 MIDDAY</td>
<td>1st Panel: Innovative Trends in Project Management</td>
</tr>
<tr>
<td></td>
<td><strong>Wagner, Reinhard; President of IPMA Mundial, GERMANY</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Valle, José Angelo; ICEC Vice President Technical, BRAZIL</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Albergarias, Raphael; President of IPMA Brasil, BRAZIL</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Cheung, TT; Vice President of ICEC, HONG KONG</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Dias, Paulo; ICEC's Region 1 Director, BRAZIL</strong></td>
</tr>
<tr>
<td>12:30 P.M.</td>
<td>Lunch (Restaurant at Queluz Room - First Lower Level)</td>
</tr>
<tr>
<td>1:30 - 3:30 P.M.</td>
<td>Parallel Session</td>
</tr>
<tr>
<td>3:30 - 3:50 P.M.</td>
<td>Coffee Break (Hall 1st floor)</td>
</tr>
<tr>
<td>3:50 - 6 P.M.</td>
<td>Parallel Session</td>
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## DETAILED PROGRAMME (General)

### Tuesday, 11th October

<table>
<thead>
<tr>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>7:30 A.M.</td>
<td>Registration of Delegates</td>
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<tr>
<td>8:30 - 10 A.M.</td>
<td>2nd Panel: The Reality Of Cost Engineering Worldwide - I</td>
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<tr>
<td></td>
<td>Nalewailk, Alexia; ICEC Chairman, USA</td>
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<td></td>
<td>Julie Owen, Julie; AACEi Past-President, USA</td>
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<td></td>
<td>John Livengood; AACEi President-Region 1, USA</td>
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<td></td>
<td>Rocha, Márcio; IBEC, BRAZIL</td>
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<tr>
<td>10 - 10:20 A.M.</td>
<td>Coffee Break (Hall 1st floor)</td>
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<tr>
<td>10:30 - 12 (MIDDAY)</td>
<td>3rd Panel: The Reality Of Cost Engineering Worldwide - II</td>
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<td></td>
<td>Smith, Peter; ICEC Secretary General, AUSTRALIA</td>
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<td>Ray, Alec; ACOSTE - Director, UNITED KINGDOM</td>
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<td>Muse, Alan; RICS, UNITED KINGDOM</td>
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<td></td>
<td>Di Castri, Gianluca; ICEC's Region 2 Director - Europe - Director, ITALY</td>
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<tr>
<td>12 - 1:30 P.M.</td>
<td>Lunch (Restaurant at Queluz Room - First Lower Level)</td>
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<tr>
<td>1:30 - 3:30 P.M.</td>
<td>Parallel Session</td>
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<tr>
<td>3:30 - 3:50 P.M.</td>
<td>Coffee Break (Hall 1st floor)</td>
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<tr>
<td>3:50 - 6 P.M.</td>
<td>Parallel Session</td>
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<tr>
<td>8 P.M.</td>
<td>Gala Dinner</td>
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<td></td>
<td>(Cocktail + Gala Dinner with ICEC Biennial Grand Solemnity)</td>
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<td></td>
<td>Room: Louvre and Versailles - Ground floor (Windsor Barra Hotel)</td>
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### Wednesday, 12th October

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>9:00 A.M.</td>
<td>Registration of Delegates</td>
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<tr>
<td>9 - 10 A.M.</td>
<td>Parallel Session</td>
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<tr>
<td>10 - 10:20 A.M.</td>
<td>Coffee Break (Hall 1st floor)</td>
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<tr>
<td>10:30 - 12 (MIDDAY)</td>
<td>4th Panel: Public Construction Bids.</td>
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<td></td>
<td>Dias, Paulo; ICEC's Region 1 Director, BRAZIL</td>
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<td></td>
<td>Dórea, Aldo; AACE Brasil President, BRAZIL</td>
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<td>Espinosa, Diana; SCI President, COLOMBIA</td>
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<td>Jr. Speight Calvin, Counselor of RICS, EUA</td>
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<tr>
<td>12 - 1:30 P.M.</td>
<td>Lunch (Restaurant at Queluz Room - First Lower Level)</td>
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<tr>
<td>1:30 - 6 P.M.</td>
<td>Final Plenary</td>
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EXHIBITORS

IBEC
www.ibec.org.br

ICEC - PAQS
www.icecpaqs2018.com

Marinha do Brasil
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Funasa
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Aligning Competitive Strategies with BSC’s Perspectives and Project Portfolio Management: a conceptual model

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²nikiforos@facc.ufrj.br
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ABSTRACT

This paper presents a proposal that enables the deployment of business strategy, based on the integration between Strategy and Project Portfolio Management, motivated by the observation that organizations find difficulties in the implementation of strategies and connecting them to their projects. The result of this misalignment is project execution without a systemic, coordination and synchronized impact of strategies without the cause-effect relationship between Strategy and projects. The bases of this study is a literature review, with three foci: Strategy using the Generic Competitive Strategies proposed by Porter (1996), the Balanced Scorecard and Strategy Maps tools, proposed by Kaplan and Norton (1196, 2004); and the pillar of Project Portfolio Management (PPM), based on a proposal by the Project Management Institute (PMI, 2008). Furthermore, a methodology for PPM, based on the PMI concepts are introduced, that enables the fusion between Strategic Planning and Projects, with the Project Portfolio Management. This paper contributes to the decision maker with an examining guideline to examine each project within the overall perspective of strategy, working as a facilitator and encouraging the project manager to have a better understanding of the role and importance of the project in compliance with the overall strategy of the Corporation.

1. The context:

Since the 50’s, organizations are concerned with macro-environmental changes and the results that it could generate in the future of their organizations. The environment has changed, and have become more complex and dynamic changing the inter-organizational and intra-organizational relationships and way of thinking. Due to the change that was taking place, several scholars began to analyze and search to understand the new dynamics (ACKOFF, 1970).
The first stirrings of that evolution occurred in the mid 50’s, especially after the Second Industrial Revolution, when the Systems approach came through. 50 years after, organizations have become more concerned about the environment and the problems surrounding them and the lack of awareness about the needs of the market.

According to Ansoff (1981), the solution to these problems lied in Strategic Planning by choosing the optimal strategy and seeking to deploy it properly.

Since the 60s and 70s, changes have accelerated in the corporate environment. Development of new technological processes, enhancement of skills and new market opportunities started to burst in a short period of time. Depending on what was happening in the environment the spread of new technologies accelerated within organizations and, mostly because its appearance and new administrative tools, the decision makers came to have greater success in the face of increasing uncertainties of the future (ANSOFF, 1983).

2. The Strategic Management:

According to Drucker (1981), Planning is a process of interrelated and interdependent actions aimed at the achievement of objectives. Moreover, he argued that planning is not about future decisions, but the future implications of present decisions. The alignment of Projects with Strategic Planning is key to the PPM (Portfolio Project Management). This connection enables the company to forecast the results expected by the product created by the project. To clarify the context some terms need to be introduced: Mission and Vision.

Mission: Defines the fundamental purpose of an organization, basically describing why it exists and what and how it does its businesses to achieve its Vision.

Vision: Defines the desired or intended future state of an organization in terms of its fundamental objective and/or strategic direction. Vision is a long term view, sometimes describing a view of how the organization would like to be perceived and valued by the market in which it operates to be.

The Strategic Plan is a set of decision-making statements made to achieve goals in the short, medium and long term, and is often developed by the top-management of organizations. The Strategic Planning does not intent to anticipate future decisions, but the future implications of decisions taken in the present time. Considering the hierarchical levels three types of planning can be defined:

- **Strategic Planning:** defined as a management process that seeks to provide the direction to be suggested by the whole company in order to obtain an alignment in the company’s relationship with its environment. It is the responsibility of the highest ranks of the company, with goals’ formulation and selection of courses to be followed, taking into account external and internal factors and their expected evolution.

- **Tactical Planning:** The purpose is to optimize a specific area or function within the company, working with decompositions of goals, strategies and policies previously established in the Strategic Plan. It
is designed to the middle and lower organizational levels and its main purpose is the efficient use of available resources to achieve objectives that were set according to a predetermined strategy and following policies to guide decision-making process of the company.

- **Operational planning:** Consists of formalization of strategies and tactics through process design, development methodologies and deployment established, in action plans or operational plans that are part of the homogeneous tactical planning. The operational plans should include: resources for their development and deployment, basic procedures to be adopted, and products or outcomes expected, the deadlines and responsible for implementation and deployment.

![Three levels of strategy](image)

**Figure 1:** Three levels of strategy  
**Source:** Adapted from Drucker (1981)

Projects can be understand as a tactical operational planning, which translates the strategic planning in a reliable outcome, always related in creating a new product, allied with one or more strategic objectives.

Strategic objectives are intentions of the organization that together define its reason to exist. It may be so broad or abstract, such as increasing market share and production with the same available resources, reduce operating costs and maintain the same financial cost, and thus increase the liquidity ratio of the organization. Yet the goals most often are far from everyday reality of the organization. Objectives can be broken down into departmental goals, so that may be detailed in operational terms, in accordance with its lines of business.

Drucker (1981) states that profit is not a cause but a consequence, the result of the company’s performance in marketing, innovation and productivity. It is a necessary result, the service of essential economic functions. Profit is the first test of performance - the only effective test. In fact, profit is a beautiful example of what coach’s mean when they talk about feedbacks that are behind all automated production systems: self-regulation of a process for their own results. Moreover, the profit function has a second, equally important. It is the risk premium of uncertainty. Economic activity because it is an activity, turns to the future, and the only thing certain about the future is its uncertainty, its risks. (HINKS, 1931)

After the strategic objectives were chosen, a set of actions are initiated: the actual situation should be
analyzed, and the path to build the vision must be defined. In this moment, one reliable tool is the key, to perform a trustful strategy. The Key Performance Index (KPI), is the measure in the company’s core activities processes that show how health the company is. Kaplan and Norton, created a new way of interpret indexes though the Balanced Scorecard (BSC):

The Balanced Scorecard translates mission and strategy into objectives and measures, organized according to four different perspectives: financial, customer, internal processes and learning and growth. The ‘scorecard’ creates a structure, a language to communicate the mission and strategy, and uses indicators to inform employees about the drivers of current and future success. By articulating the desired results by the company with the vectors of these results, executives hope to channel the energies, skills and expertise of people in the entire company to achieve the long-term goals. So if the measure points to a problem, an intervention will be required: the creation of a project to fix the low score, adding value to the company. (Kaplan & Norton, 1997, p. 25)

With the introduction of the Strategic Maps, the decisions made could convert intangible assets into tangible outcomes. In other words, the strategic objectives could be assembled together in a map with all the important indexes, and relations between that indexes that creates value to the organization. To clarify the concept, Kaplan and Norton divided the map in four perspectives that are correlated in order to create synergy among them. Below they are described:

- The financial perspective: examines if the company’s implementation and execution of its strategy are contributing to the bottom-line improvement of the company. It represents the long-term strategic objectives of the organization and thus it incorporates the tangible outcomes of the strategy in traditional financial terms. The three possible stages as described by Kaplan and Norton (1996) are rapid growth, sustain, and harvest. Financial objectives and measures for the growth stage will stem from the development and growth of the organization which will lead to increased sales volumes, acquisition of new customers, growth in revenues etc. The sustain stage on the other hand will be characterized by measures that evaluate the effectiveness of the organization to manage its operations and costs, by calculating the return on investment, the return on capital employed, etc. Finally, the harvest stage will be based on cash flow analysis with measures such as payback periods and revenue volume.

- The customer perspective: defines the value proposition that the organization will apply to satisfy customers and thus generate more sales to the most desired (i.e. the most profitable) customer groups. The measures that are selected for the customer perspective should measure both the value that is delivered to the customer (value proposition) which may involve time, quality, performance and service, and cost, and the outcomes that come as a result of this value proposition (e.g., customer satisfaction, market share). The value proposition can be centered on one of the three: operational excellence, customer intimacy or product leadership, while maintaining threshold levels at the other two.
The internal process perspective is concerned with the processes that create and deliver the customer value proposition. It focuses on all the activities and key processes required in order for the company to excel at providing the value expected by the customers both productively and efficiently. These can include both short-term and long-term objectives as well as incorporating innovative process development in order to stimulate improvement. In order to identify the measures that correspond to the internal process perspective, Kaplan and Norton propose using certain clusters that group similar value creating processes in an organization. The clusters for the internal process perspective are operations management (by improving asset utilization, supply chain management, etc.), customer management (by expanding and deepening relations), innovation (by new products and services) and regulatory & social (by establishing good relations with the external stakeholders).

The innovation and learning perspective is the foundation of any strategy and focuses on the intangible assets of an organization, mainly on the internal skills and capabilities that are required to support the value-creating internal processes. The Innovation & Learning Perspective is concerned with the jobs (human capital), the systems (information capital), and the climate (organization capital) of the enterprise. These three factors relate to what Kaplan and Norton claim is the infrastructure that is needed in order to enable ambitious objectives in the other three perspectives to be achieved. This of course will be in the long term, since an improvement in the learning and growth perspective will require certain expenditures that may decrease short-term financial results, whilst contributing to long-term success.

The Balanced Scorecard offers a framework for describing strategies for creating value. Kaplan and Norton (2004, pag.7), declare the BSC framework has several important elements:

Financial performance, a lag indicator, provides the ultimate definition of an organization’s success. Strategy describes how an organization intents to create sustainable growth in shareholder value. Success with targeted costumes provides a principal component for improved financial performance. In addition to measuring the lagging outcome indicators of customer success, such as satisfaction, retention, and growth, the customer perspective defines the value proportion for targeted customer segments. Choosing the customer value proposition is the central element of strategy.

Internal processes create and deliver the value proportion for customers. The performance of internal processes is a leading indicator of subsequent improvements in customer and financial outcomes.

Intangible assets are the ultimate source of sustainable value creation. Learning and growth objectives describe how people, technology and organization climate combine to support the strategy. Improvements in learning and growth measures are lead indicators for internal processes, customer, and financial performance.

The BSC is a method to measure the success of the strategy planning. The base for strategic planning is what strategy the organization will choose. The theory of competitive generic strategies (Porter, 2005), introduce three types of positioning for a company:

- Differentiation - Differentiation strategies aim at the broad market that involves the creation of
products that are perceived throughout its industry as unique. The company or business unit may, then, charge a premium price for its product. This uniqueness can be associated with design, brand image, technology, features, dealers, network, or customers service. Differentiation is a viable strategy for earning above average returns in a specific business because the resulting brand loyalty lowers customers' sensitivity to price. Increased costs can usually be passed on to the buyers. Buyers loyalty can also serve as an entry barrier-new firms must develop their own distinctive competence to differentiate their products in some way in order to compete successfully.

- **Cost** - This strategy emphasizes efficiency. By producing high volumes of standardized products, the firm hopes to take advantage of economies of scale and experience curve effects. The product is often a basic no-frills product that is produced at a relatively low cost and made available to a very large customer base. Maintaining this strategy requires a continuous search for cost reductions in all aspects of the business. The associated distribution strategy is to obtain the most extensive distribution possible. Promotional strategy often involves trying to make a virtue out of low cost product features.

- **Focus** - In this strategy the firm concentrates on a select few target markets. It is also called a segmentation strategy or niche strategy. It is hoped that by focusing your marketing efforts on one or two narrow market segments and tailoring your marketing mix to these specialized markets, you can better meet the needs of that target market. The firm typically looks to gain a competitive advantage through product innovation and/or brand marketing rather than efficiency. It is most suitable for relatively small firms but can be used by any company. A focus strategy should target market segments that are less vulnerable to substitutes or where a competition is weakest to earn above-average return on investment.

![Figure 1: Porter’s Generic Competitive Strategies](Source: Adapted from Porter (1996))

According to the strategic position that the company chooses, and the measure of the performance, managed through the BSC, new projects and programs can be selected, and the existing ones can be evaluated vis-a-vis the expected benefit. That is the base to justify the use of Portfolio Project Management: to understand how much value the project is creating, and what strategic objective is connected with
that strategic intervention (projects and programs). The main objective is to allow the company to have a sustainable competitive advantage.

3. Portfolio Project Management (PPM)

No company have sufficient resources to research everything about one´s business needs, even in the best case scenario. It is certainly even truer when times are hard. Even if a company has all the resources necessary; definitely it does`nt have the ability or all people skills to complete all that is needed. The typical response to managing scarce resources against an surplus demand is to propose some kind of ordering process to ensure that it approves and establishes the work that will provide the most value.

The market is familiar with the term “Portfolio Management” in the financial approach. The term implies that a professional manages the money in a way that maximizes return and minimizes risk. As organizations have a limited amount of resources to apply in their businesses. The resources must be utilized to maximize the value and enable it to achieve its goals outlined in the strategic planning. Applying a methodology of Portfolio Management is a way to maximize the return of the organization.

The best way of manage a portfolio is to understand that the use of resources should provide an effect that is beyond sum of efforts, but a multiplication, the synergy means that is the multiplier effect. The synergy between the Strategic Planning and PPM occurs when using the same resources, produces a result greater than could be achieved with the use of these resources alone, and leads to the need for a system of goals and overall results through the strategic maps are demanding for.

If the future is coming - and he always arrives at any time – it seems that no company is adequately prepared to confront him about to improvise solutions that floods are not always the best. Hence the simplistic mentality of solving problems as they arise in every moment, in business, making them more reactive to events than proactive in relation to events that occur in a world full of changes.

In this context, the PPM emerges as a tool to the organizations to define, in accordance with its strategic objectives; which strategic interventions (Programs and Projects) should be included and performed to keep the highest level of aggregation to the organizations.

The next question asks if the feature is actually implemented and that creates the greatest value to the organization, within the highest priority. This response is obtained in the Strategic Plan of the company. This is a question that cannot be answered in isolation. What really needs to be understood is that the overall strategic planning, and where the company is positioned.

After the understanding of the context that the organization is into, the PPM provides some of the following steps to organize the Company's Portfolio (PMI, 2006):

- To identify the possible projects / programs that can add value to the organization, according with the strategic planning;
- To categorize the identified projects / programs according to the strategic objectives;
• To select the projects / programs, aligning with the strategy map;
• To prioritize the projects / programs, according a preliminary evaluation of the possible expected returns of each project / program;
• To balance the Portfolio – analyzing the inclusion of the new projects / programs, into the existent portfolio to evaluate the impact on the company current operation;
• To authorize and manage all work in the organization. This includes work that was completed, work in progress and work that have been approved for the future.

Further, it helps to bring the baseline that can be subsequently used to measure how well the portfolio is managed to meet the needs of the company, based on its Strategic Planning. Thus comes the definition, aimed at an audience of project management, management of the Portfolio is to organize the project portfolio of the corporation, thus deserving of special importance due to the impacts, positive and negative, which can cause the same. (PMI, 2006)

Given the demand hierarchy, in its definition due to the alignment of corporate strategic planning, the project portfolio (portfolio), therefore, is to bring integration and organization of programs and projects of companies, these by definition, projects are grouped by their affinities technical, operational and strategic within the context of the formation of end products such as designs are concerned to perform the activities, abstracted from much of the strategic vision of the company (PMI, 2006).

4. Strategy-Project-Control Alignment Model

Once the above-mentioned concepts have been introduced, Project Managers and Sponsors need to align strategy, project, portfolio and program management and control, mainly in international corporations. Figure 2 synthetizes the proposed conceptual model to support project management in all levels of the corporation. Firstly, corporate goals should be understood and separated by business unit, segmented markets and/or specific resources, skills and procedures specialization.

Secondly, in order to achieve these goals, specific generic competitive strategies need to be defined. Porter (2005) states that those specific strategies demand specialized assets and other resources that cannot be managed together with the risk of misalignment among them, causing the organization to be “stuck in the middle”, so specific strategies, at SBU level, are better aggregated by type, as show in Figure 2. Lastly, the balanced scorecard should be envelope taking onto account that specific strategies will need specific indicators, with a more weighted-balance in some indicators, instead of others.

As an example, Differentiation strategies should rely on high margin targets and more revenue from the main product and conjoint accessories and services, with high customer satisfaction and state-of-the-art product delivery, based in top-of-the market employees, colaborators and partners. On the other hand, Cost Leadership strategies should rely on high turnover and low margins (but above market average), good price-to-value perception from customer base and highly standardized and efficient product delivery, made by rigid- procedures and highly standardized employee-service. Once strategies are defined to achieve the specific goals and BSC has been deployed to evaluate strategy implementation and return
thru the specific indicators and targets, projects can be put together and sponsored by structures that share the same knowledge, culture, skills and resources.

Thus, Differentiation strategies will deploy premium products with high-value and market price, to supply highly-demanding customers (mostly, innovators and first-users) that use exclusive channels of distribution and communication. Quality scope control is extensive to this type of product clients and any project manager that will deal with this audience needs to emphasize customer satisfaction indicators (stakeholder management) achieved by a team highly trained in both technical and interpersonal skills, not bothering to costs but delivery on time and as defined. Cost leadership strategies will develop cost and time strict scopes, high level of standardization in process and more Time Management. The same will be to focus projects that will need to have interchangeable resources coming from and to the other two types of strategies.

Finally, as projects are going to be categorized by their strategic goals, specific sponsorship and project management structures need to be deployed. Portfolio management can be done by aggregating high-value and differentiated products to be delivered, needing a stronger political sponsorship from the CEO or, even, the Executive Board while Cost-driven projects can be sponsored by local VPs or Directors. Project Management Offices need to be defined according to project size, quantity, level of complexity, time and investment deployed in order to define if one PMO can manage more than one kind of projects. Different structures and back-office services can be deployed according to the depth of process, procedures and tasks to be from the basic functional backup from a functional structure (in the case of cost-reduction and process development and improvement projects) to specific PMOs with multiple projects (portfolios) and Shared Services Centers (SSC) to optimize basic tasks and consolidate Procurement, Contract Management, and even Documentation generating qualitative final reporting and learned-lessons archives.

Through Integration Management, not only the different areas and phases of projects can be seen and evaluated but also the overall corporative goal can be scanned in a more constant basis, by the use of BSC flight panels, showing the major stakeholders – boards, shareholders committees, holding executives and investors – the advances of all projects, the overall portfolio and programs designed to achieve the desired goals. One factor this proposed model tries to avoid is aggregating different projects and portfolios in the same organizational space, with the multiple skills and employee profiles and using the same resources in order to avoid misalignment of strategic views, resource allocation conflicts (other than limited resources) and political struggle.

Cost leadership projects, for example, will manage products that deliver mass production output, with basic standardized products and processes and need to deliver the product within strict time and cost. Differentiation projects will accept cost and time augmentation in order to achieve the high standard of quality for the delivered product. By dealing differently and separately with different competitive strategies, not mixing projects in the same PMO or under the same sponsorship, the proposed model tries to avoid possible project pitfalls, such as strategy-structure misalignment, mistaken human resource allocation and mistakes in Procurement, third parties hiring and wrong expectations in performance indicators.
| Corporate goals (profitability, ROA, ROI, Share value and other investment indicators) |
| Through these indicators, corporations and holding define their areas of investment... |
| ... and develop, deploy or invest in Strategic Business Units with proper Generic Competitive Strategy. |

| These different SBUs have specific strategies and, therefore, need specific assets and indicators. The BSC focus is used to aggregate specific indicators in criteria by Competitive Strategy, as shown below. |

<table>
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<tr>
<th>BSC Perspectives</th>
<th>Array of Generic Competitive Strategies (according to their SBUs)</th>
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</thead>
<tbody>
<tr>
<td><strong>Financial Perspective</strong></td>
<td><strong>Differentiation</strong></td>
</tr>
<tr>
<td>High margin indicators, Conjoint sales and revenue from aggregated services and accessories</td>
<td>High to medium margin indicators, Narrower client basis conjoint sales in specific segmented markets</td>
</tr>
<tr>
<td><strong>Client Perspective</strong></td>
<td><strong>Excellent Customer satisfaction, Brand advocacy, Continuous relationship</strong></td>
</tr>
<tr>
<td><strong>Process Perspective</strong></td>
<td><strong>High level of operational efficacy, Breakthrough innovative procedures and technology, Taylor-made solutions</strong></td>
</tr>
<tr>
<td><strong>Innovation and Learning Perspective</strong></td>
<td><strong>State-of-the-Art design and technology, Highly skilled personnel and Matrix and/or Project-Driven Structures</strong></td>
</tr>
<tr>
<td><strong>Portfolio Management Structure and Sponsorship</strong></td>
<td><strong>CEO sponsorship, CEO-supported and directly-connected PMOs</strong></td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td><strong>Possible shared activities and skills (Shared services centers)</strong></td>
</tr>
<tr>
<td><strong>Program Management</strong></td>
<td><strong>Strategic and Tactical Evaluation (ERP, BSC and Financial Analysis)</strong></td>
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**Figure 2:** Strategy-Portfolio-Control Framework

**Source:** The authors (2015)
5. Conclusion

The projects and programs can be understood as strategic interventions. This intervention must create value to the organization, and more than that: must have a specific purpose. To translate this proposes in reality, the projects and programs must be connected with one or more strategic objectives. As was said this objectives could be translated by BSC in a strategic map that clearly shows the indexes that translate the mission and vision of the company, which is based on one of the three generic strategies proposed by Porter.

Thus we arrive at the definition of programs as a coordinated set of projects, aimed for in common, the Portfolio Management have the perspective of a portfolio of projects of the corporation, thus deserving of special importance due to the impacts, positive and negative can cause the same, always looking for creating value for the organization and develop a sustainable competitive advantage.

6. Bibliography


Estimation costs in sanitation engineering projects: a methodological proposal

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ABSTRACT

Purpose of this paper

This paper will propose a methodology to estimate the time-cost relationships in Order of Magnitude Estimate (Class 5 and 4 – AACE) from a budget database (Class 2 – AACE) for sanitation projects in Brazil.

Design/methodology/approach

We use the parametric method based on the S-curve to clustering similar projects. A mixed-effects model approach to determine the fixed component of the cost estimating relationships (CER's), to increasing the estimating accuracy.

Findings and value

Data analysis confirmed the time-cost non-linearity for the projects evaluated. Tree clusters were identified and then a non-linear mixed-effects model was used to extract the fixed and random parameters from clusters.

Research limitations/implications

The database used in this work is related to sanitation projects, though the methodology can be used in other areas of interest.

Practical implications

The proposal allows calculate the theoretical cash flow for the project detailing the fixed and random components. Stakeholders can use this methodology to assist in decision making in the previous phases to FEL 3 (Gates 1 and 2 - AACE).
Originality/value of paper

This is the first study in Brazil to using a mixed-effects model for cost estimation. Is also the first to provide parameters for Order of Magnitude of sanitation projects. For instance, this allow a municipalities use the method to preparing budget forecasts.

Conclusions: This study provide some useful methods to estimate costs, increasing accuracy through the classification of database projects (beginning, middle or end) and use of mixed-effects. On the other hand, provides parameters for Order of Magnitude of sanitation projects.

Keywords: cost estimating, order of magnitude estimate, sanitation, S-curve, nonlinear mixed-effects model

1 INTRODUCTION

The cost estimating is the predictive process used to quantify, cost, and price the resources required by the scope of an investment option, activity, or project (PMI 2013) for determining the economic feasibility of a project and establishing the project budget.

Many are the theories and practices of the fundamentals of costing calculations. However, estimate is reliable pre-requisite of calculation, its parameters and resulting indexes can be used to form new budgets, besides controlling budgetary mistakes.

First, in Brazil they are not know indexes disclosed to generate estimates of Order of Magnitude Estimate; its affecting negatively the quality of estimate in government-funded projects. Second, some good studies are focused on cost estimates for industrial and civil engineering (Conforto and Spranger 2002), but the sanitation area not have been sufficiently studied. Third, when indicators are debatable or complexes is necessary the creation of new concepts and methodologies.

The integration of the project cost estimate with the project schedule and cost control system is crucial for effective project management and control. The collection and analysis of previous project cost data in order to develop the cost estimating relationships (CER's) (Amos 2007). Therefore, the idea of the current study was proposing a methodology to estimate the time-cost relationships, specifically in sanitation projects.

2 METHODS

2.1 Database

In this study the data was compiled from a population of 31 budgets projects of municipalities in the São Paulo state, contemplated by Brazilian Federal Government programs.

The samples were of sanitation projects (water supply systems - SAA and sewage systems - SES) from 2007 to 2014. The physical and financial schedule was collected with detail level of Class 2 - AACE and a
range from 5 to 19 data points, were excluded projects with less of 5 point because

2.2 Materials

The data analysis was processed using KNIME (Berthold et al. 2009) and R (R Development Core Team 2016), also used in the parameterization, statistical inferences, modelling and plotting (Wickham 2009). See the Figure 1 which shows the flowchart of the methodology applied:

Figure 1: Methodology workflow.

After the database compilation were normalized the time and cost values by scale range (0 to 1). An analysis by preliminary nonparametric local regression was applied to verify the baseline driver for the model (see Figure 2).
2.3 Procedure

2.3.1 Parametrization

At an initial parametrization was checked the linearity with the assessment of linear model assumptions (skewness, kurtosis, heteroscedasticity and link function), this design was used to control in a level of significance = 0.05. However, the time-phased view of the cost baseline is typically nonlinear and displayed in the form of an S-curve (PMI 2013).

In addition, the logistic function was adopted to compose the parametric model (ISPA 2008) of S-curve because is relatively simple and have tangible parameters (L, k, x0):

where \( f(x) = \text{cost}; x = \text{time}; L = \text{the curve's maximum value}; e = \text{the natural logarithm base (Euler's number)}; k = \text{the curve's steepness}; x_0 = \text{the x-value of symmetric inflection point}; \) and \( \varepsilon = \text{the random error (for mixed-effects model). The terms } f(x) \text{ and } x \text{ have been normalized by scale range (0 to 1), resulting in } L = 1. \)

\[
f(x) = \frac{L}{1 + e^{-k(x-x_0)}} + \varepsilon
\]  

(1)
2.3.2 Clustering

After, the parameters \( k \) and \( x_0 \) were determined for each project by calculating the best fit nonlinear least-squares of the Equation 1. Then was applied the clustering technique to group the similar projects curves to keep the parameterization representability without leave off marginal projects. Next, was determined the optimal number of clusters for the best clustering scheme (Charrad et al. 2014), 3 clusters.

Then proceed the grouping testing various algorithms like Divisive Hierarchical, Fuzzy, Hierarchical, k-means and other variants (Maechler et al. 2016) and chosen the more suitable method based in cluster indexes (size, diameters, separation, silhouette, Dunn index) and visual comparison. For additional control, Fuzzy is used to assign a prior probability to data point and cluster membership (see Figure 3).

Then a logistic curve was adjusted for each cluster (1, 2 and 3, 0 is a generic overall) used to control; obtaining the characteristics terms \( k \) and \( x_0 \) of each group. The control of the goodness of fit and model’s predictive performance were based on the estimate of residual standard deviation (\( \sigma \), sigma) and the Spearman’s (\( \rho \), rho) correlation coefficient. These are more robust and have been recommended for the nonlinear regressions.

2.3.3 Mixed-effects approach

Finally, each project in a cluster was considered a repeated measurement of related statistical units (longitudinal data of similar projects). Mixed-effects are flexible to obtain the fixed-effect (estimate the projects level coefficients) and random-effects, to account for individual differences in response to an effect.

The fixed effect accounts for the part which directly manipulate and is often repeatable. The random effect estimates the variability caused by individuality (location, year, characteristics of served population, project size, project objective, magnitude of final cost, etc.). The mixed-effects were implemented (Pinheiro J et al. 2016) as fixed-effect curve and the randomness smooth for a 95% confidence interval in each cluster and 95% prediction interval of all.

3 RESULTS

Unexpectedly, the linearity check found that approximately one-third of projects accept a linear correlation of time-cost. The Fuzzy method was chosen for the clustering (see Figure 3) by logistic curve terms \( k \) and \( x_0 \). Advantageously, nearly all projects admitted by the linear assumptions were members of cluster 1, so this group was used as the control group.
We found support for the hypotheses that parametrization of S-curve can be the logistic equation through the great indexes (sigma and rho) of goodness of fit (see Figure 4). As expected, the mixed-effects approach was not only increase the precision, but mainly the accuracy. Furthermore, allowed the visual differentiation of fixed and random components of each group (see Figure 5, the generic overall 95% prediction interval is the dotted blue area).
Figure 4: Fit a Logistic Curve by cluster.

\[ f(x) = \frac{1}{1 + e^{-k(x-x_0)}} \]

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>k1</td>
<td>x0</td>
<td>5.563</td>
</tr>
<tr>
<td></td>
<td>σ1</td>
<td>0.4726</td>
</tr>
<tr>
<td></td>
<td>σ2</td>
<td>0.0518</td>
</tr>
<tr>
<td></td>
<td>p1</td>
<td>0.9888</td>
</tr>
</tbody>
</table>

Figure 5: Mixed-Effects approach to fit a Logistic Curve by cluster.

\[ f(x) = \frac{1}{1 + e^{-k(x-x_0)}} + \epsilon \]

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>k1</td>
<td>x0</td>
<td>5.597</td>
</tr>
<tr>
<td></td>
<td>σ1</td>
<td>0.4735</td>
</tr>
<tr>
<td></td>
<td>σ2</td>
<td>0.0425</td>
</tr>
<tr>
<td></td>
<td>p1</td>
<td>0.9933</td>
</tr>
</tbody>
</table>

| k2      | x0         | 7.264  |
|         | σ2         | 0.5858 |
|         | σ2         | 0.03874|
|         | p2         | 0.9957 |

| k3      | x0         | 6.541  |
|         | σ3         | 0.47   |
|         | σ3         | 0.04363|
|         | p3         | 0.9588 |
We find the indicative range of values of $k$ and $x_0$ (see Figure 6), there was no evidence or correlation that justifies the separate study of the types of sanitation project (SAA and SES). Overall, we found 3 typical projects associated to the occurrence of the higher cost period on the project life-cycle:

- **beginning:** cluster 3
- **middle:** generic overall (cluster 0) and cluster 1 (control group)
- **end:** cluster 2

Figure 6: Mixed-Effects representation plot by cluster.

### 4 DISCUSSION

The purpose of this study was propose a methodology to estimate the time-cost relationships, specifically of Brazilian sanitations projects. We tested the hypothesis that the use of the logistic function in non-linear modelling with excellent results. It is consensus that projects a straight cumulative cost curve does not correspond to reality.

The fact of most of the projects who agreed the linear correlation were grouped in the cluster 1 are not easily explained. However, in Brazil we postulate that this is because many estimates Classes 4 and 5 are used directly for tenders, tender or budget authorization (should be Class 2).
The findings of mixed-effects are consistent utilization, especially for comparison with the control group, suggesting the use of fixed terms in the forecast. Future research of k and x0 terms from other local and organizations could contribute in several ways.

In conclusion, the results of this study provide some useful methods to estimate costs, increasing accuracy through the classification of database projects (beginning, middle or end) and use of mixed-effects, allowing forecast the theoretical cash flow for the cost project estimate. On the other hand, provides parameters for Order of Magnitude of sanitation projects. This allow to use in controlling, budgets forecasts and activities of Gates 1 and 2 - AACE.

5 ACKNOWLEDGMENT

We thank the Brazilian National Health Foundation (Funasa), in particular the technicians of São Paulo State Public Health Engineering Division (Diesp/SP) for provide the raw data required to this work.

6 REFERENCES

EVM on an Engineering Company - Case

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ABSTRACT

The lack of Project Management expertise grows daily in Brazil, as well as globalization. Monitoring and controlling costs, deadline attendance and delivering the products with the quality required by the customer are no longer advantages for the companies, they are indispensable characteristics for any company survival.

Aligned with the Project Management concept, the world was introduced to the PMBOK, a standardization of processes, areas of knowledge, techniques, rules and methods that can (and should) be used in the management of any project.

This paper presents, based on a literature review, the main concepts of Project Management, such as the ten areas of knowledge and one of the main and most important techniques, the Earned Value Management (EVM), considering the required parameters for its application.

Also, it is going to be submitted a case applied on a private company engineering designer, taking as example one project budgeted at R$ 3 million, that, with the use of new measures for performance monitoring, reached a significant result of 28% saving in the budget.

Finally, as conclusion some opportunities for improvement and next steps are presented, enabling further improvements on performance of the project management in this company, making it more competitive on the current aggressive market.

Keywords: Engineering; Project Management; PMBOK; Earned Value Management; EVM.
1 INTRODUCTION

Considering the end of the 90’s and the economic recession in the United States, the necessity to adapt to globalization was knocking at the Brazil’s door. Companies started to recognize the importance of monitoring and controlling costs, meeting deadlines and delivering products with the quality required by the customer. Therefore, the concept of Project Management began to spread and be recognized. The velocity of changes that occurred at the corporative world has made companies seek to improve their competitiveness in order to survive in the market (Oliveira, 2003).

In this scenario, it can be said that the survival of any company goes through a strict control of costs, deadlines and quality of the project, in order to provide to the customer the best product or service considering the most competitive features.

With this motivation, one of the techniques most used by project managers is the Earned Value Management (EVM), which consists in manage the project development of the project in terms of quality, schedule and costs through the analysis of indicators comparing forecasted (planning) vs actual (execution).

The main objective of this paper is to demonstrate, based on a literature review, the importance of the practice of Project Management for a company and present a case where one of its main tools, EVM, is proved able to identify, correct and treating the course of an engineering project.

For that, it’s going to be used the following performance indexes: schedule (SPI), cost (CPI) and Earned Value (EV).

2 PROJECT MANAGEMENT

2.1 Background

According to Valle (2010), the project management concept was not used as an isolated concept until the climax of Cold War between United States and the Soviet Union. After the launch of Sputnik satellite by the soviets, the US Department of Defense began to invest in the development of new techniques and tools, in order to accelerate the deployment of military projects.

This effort was critical to develop the Program Evaluation and Review Technique (PERT) and, later, the DuPont company developed similar technique, called Critical Path Method (CPM).

Valle (2010) also mentions that in 1967, the US Department of Defense published the entitled Cost / Schedule Control Systems Criteria (C/SCSC), which contained more than 35 standards of management and project control, with which suppliers should be adapted. This standard was responsible for influencing the development of good project management practices in future publications.

Although inspired by military proposes, several companies began to adopt these techniques, mainly impacted by external factors, such as:
- The need to practice a reengineering in its internal processes, in order to eliminate work that could not add value to the final product;

- The advent of globalization, due to the growing economic interdependence between countries, made that the transnational companies sought to standardize the way to manage projects in order to make possible that teams in different countries could work collaboratively in order to achieve common goals in pre-established deadlines;

- The increasing use of computers continued, allowing that many project management tools, such as PERT and CPM, were available for most project managers;

- And the Internet, due to its ability to share information and documents instantly, integrating, than, a large number of geographically dispersed people, strengthening the management by projects.

2.2 Definitions

Companies need greater efficiency and velocity to meet the market demands, making that the projects respect the tripod quality, cost and time. To get it right, the management must follow the guidance of a methodology, including planning, execution and control, established by the community.

The standard covered in this study was defined by PMI (Project Management Institute) and has been adopted by many companies. This standard can be studied in the PMBOK (Project Management Body of Knowledge) manual, which seeks to approach the main issues that can be addressed in the management of a generic project. This is not a project management methodology, it is a standardization, which identifies and nominates processes, areas of knowledge, techniques, rules and methods.

This standardization was recognized in 1999 as a project management standard by ANSI - American National Standards Institute.

2.2.1 PROJECT

According to the PMBOK, 5th edition (2013), a project is “a temporary venture, that consists in create a product, service or result, which should be single.”

Projects differ from processes or operations because these are continuous and repetitive, while projects are temporary and unique character. They are temporary because every project has a set beginning and end. They are considered single because the product or service is somehow different from other products and services, even though from same or similar areas.

Projects could be created at any organization level, on a single department at the company or outside its borders, as in joint ventures or partnerships. Frequently, the projects represent critical components of the company’s business strategy.
2.2.2 PROCESS GROUPS

The project management processes organize and describe the realization of the project. The PMBOK documents five process groups, which are interrelated and dependent on each other (Valle, 2010):

1. Initiation - responsible for formalizing the existence of a project for the organization, set the goals and initial scope, naming the project manager and to authorize the mobilization of resources for their realization;

2. Planning - determines, more precisely, what should be done, according to scope statement, and how it should be done, according to the project management plan. The registration of these settings is done in a baseline containing the plan against which the results will be compared;

3. Executing - produce the project deliverables through people, organization and resource materials integration;

4. Monitoring and Control - responsible for evaluates the results of execution analysing the baseline set in Planning. If deviations are identified, corrective actions should be taken;

5. Closure - process group that formalizes the project closing, the results' acceptance, the official contracts' closing and the team demobilization.

Each process group above is composed by a different number of individual processes. The set of all this processes configure the process of Project Management.

Figure 1 - Effort vs Project Management Group Processes
2.2.3 PROJECT MANAGEMENT

The PMBOK 5th edition (2013) defines project management as “the application of knowledge, skills, tools and techniques on project activities in order to meet their requirements.” It can be better explained through the processes that compose it, which can be divided into five groups of processes - Initiating, Planning, Executing, Controlling and Closing - and in ten Knowledge Areas - Integration Management, Scope Management, Time Management, Cost Management, Quality Management, Human Resources Management, Stakeholders Management, Communications Management, Risk Management and Procurement Management.

The project team manages the work involved in Project Management, which usually involves:

- Balancing competing demands of scope, time, cost, risk and quality of the project;
- Satisfaction of different stakeholders with different needs and expectations;
- Achievement of established requirements.

The Project Management term is sometimes used to describe an organizational approach to the management of routine operations. This approach deals with many aspects of routine operations as projects to apply Project Management techniques to them, which is also called management by projects.

2.2.4 PROJECT MANAGEMENT KNOWLEDGE AREAS

Since 2013, the new version of the PMBOK groups the processes discussed on item 2.2.2 in 10 different categories, named as Knowledge Areas of Project Management. This cluster groups 47 processes in areas that have common characteristics.

These ten areas of knowledge have extensive literature and will be presented in a macro way in this work, focusing on showing some practical aspects within the Project Management. In Cost Management knowledge area is the Earned Value Analysis, this work object of study, one of the most important project control tools.

2.2.4.1 INTEGRATION MANAGEMENT

This knowledge area coordinates all aspects of the project plan and involves a high level of interaction. The integration area is concerned to meet customer and different stakeholders’ requirements and successfully manage their expectations.

The planning and project execution, the monitoring of their work and changes' control occurs throughout the project and are repeated continuously during the project execution.

2.2.4.2 SCOPE MANAGEMENT

The Project Scope Management defines all project activities necessary to fulfill the goals. Its processes, highly interactive, define and control aspects which are or not part of the project. They occur at least once during the project life cycle.
The Scope Management includes also the product’s scope (or service) and the project’s scope. In general, this is the application area that determines which tools and techniques will be used to define and manage it.

2.2.4.3 TIME MANAGEMENT

The Time Management involves estimate the project activities duration, develops the project schedule and monitors and controls the schedule deviations. This area is responsible to keep the project activities on time and to compares these activities to the project baseline, ensuring that the project is completed on time.
In most cases, especially in smaller projects, the Sequencing and Estimating Activities Duration and Schedule Development are treated as a single activity simultaneously performed by a single person.

### 2.2.4.4 COST MANAGEMENT

The activities of this knowledge area define estimates and resources costs and control these costs to ensure that the project stays within the approved budget. The center of their attention is the resources cost, but other costs should also be considered.

The Cost Management is considered by many as one of the key areas to Project Management. Good or bad performance in this area is the first item to be evaluated and what usually causes greater impact on the final results of the project.

Actually there are several ways to control the project costs, and one of the most complete, that is able to consolidate the cost, schedule and technical project performance is the Earned Value Analysis, whose technique will be presented more detailed later in this work.

In most cases, budget is the major constraint on a project, and their maintenance or improvement is the biggest Project Manager challenge. Then, he must use the best tools, techniques and professionals to ensure the best possible project costs control.

### 2.2.4.5 QUALITY MANAGEMENT

This knowledge area ensures that the project must meet the requirements with which it has been committed, focusing on the product (or service) quality and the project management process quality used throughout the project life cycle. These processes measure overall performance, monitor project results and compare them with the quality standards set out in the project planning process, to ensure that the customer receives the product (or service) that him realize to have bought.
2.2.4.6 HUMAN RESOURCES MANAGEMENT

The Human Resources Project Management covers all management and people’s interaction aspects, including leadership, orientation, conflict resolution and performance evaluations. These processes should ensure that the human resources assigned to the project are used as effectively as possible. Among the members of the project with which these skills will be practiced are the stakeholders, team members and clients, and different styles of communication, leadership and team building skills are required.

Considering that projects are unique and temporary, also are their teams. Their resources are brought together accordingly on their competencies and skills, those are relevant to carry forward the project activities. Each team is different and the stakeholders involved in each stage of the project may vary, so, to manage the processes of this knowledge area, the use of many different techniques on different project moments will be essential.

2.2.4.7 COMMUNICATION MANAGEMENT

Communication skills are general skills that the manager use most on a daily basis. Its processes aim to ensure that all project information (including project plans, risk assessments, meeting notes, and others) are collected, documented, archived and discarded when appropriate. Ensure also the distribution and sharing of information with stakeholders, management and project members at the appropriate times. At the end of the project, the information is stored and used as reference in future projects - also known as lessons learned.

All project participants have some relation to this area of knowledge, since all send and/or receive communication throughout the life of the project. It is essential that all team members and stakeholders understand how communication affects the project.

2.2.4.8 STAKEHOLDERS MANAGEMENT

The 10th area created in 5th PMBOK edition includes the processes required to identify individuals, groups or organizations that may impact or be impacted by the project. Then, analysing their expectations and their impact on project, the project manager should design and develop appropriate management strategies for effective engagement of these stakeholders on decision project’s points.

2.2.4.9 RISKS MANAGEMENT

Risks represent, at the same time, threats and opportunities. This area processes are related to the identification, analysis and response to potential risks that may affect the project. They are also useful to identify the positive consequences of risk and exploit them, in order to improve the project objectives or detect efficiencies that can improve its performance.

2.2.4.10 PROCUREMENT MANAGEMENT

This area encompasses the processes related to the purchase of goods or services from external suppliers. In this case, the project manager is the buyer, then the process should be examined from this optical.
2.2.5 THE PROJECT MANAGER PROFILE

As discussed in previous sections, the diversity of tasks that the project manager should deal with makes this person a multidisciplinary one. He should negotiate all the time and appreciate the final product (or service) quality.

Oliveira (2003) lists some characteristics and skills that professionals with different backgrounds may have or develop. Below are outlined seven human skills essential to the project manager:

1. Organization - an organized professional saves his time and allows a faster and more accurate decision. For example, if the manager spends a lot of time looking for a project document, something is very wrong;

2. Leadership - the leader is able to inspire people and "walk around" with them. He generates enthusiasm in his team, shows how to do it instead of order to do. A leader is also able to mount his team, seeking synergy between members and chooses according to multidisciplinarity required for that project;

3. Communication - Recent research conducted by PMI shows that this is the weak point of many projects. It must have a documented, comprehensive and transparent communication process, encouraging the exchange of ideas and opinions. An important addendum is to be always aware about what should and what should not be communicated to stakeholders;

4. Negotiation - the project manager should deal with different interests, making agreements that are satisfactory for both parties (relationship "win-win"), convince people to do what they do not want to, ask for more time or resources to certain tasks, and so forth;

5. Crisis Management - the project manager must be able to anticipate the crisis, mapping out the possible risks on the most important questions for the customer. In his own team, the manager should maintain a healthy stress level, avoiding the "friendly fire";

6. Problem Solving and Decision Making - the manager should have enough confidence to make decisions having not enough information available, identifying problems and proposing solutions, and acting when necessary;

7. Persistence - the project manager should confront the difficulties, having patience and insisting when necessary.

In addition to above skills, the project manager plays an important role on the corporation. Among other things, he represents the board's, top managers’ and the company's shareholders' desires and wishes. After all, for these people what basically matters is: return on invested capital and longevity guarantee. This return is closely linked to cash flow and profit margin (Cost Management), while the longevity guarantee is related to the project results and especially to customer satisfaction, responsible for provide a key position to company on the market.
The project manager must be able to have an well interaction with the technical area (knowing the product/service that is being offered, knowing how to expose it to the customer, know their technical risks and the processes involved in their development). At the same time, he must have sufficient management expertise to ensure a good project performance, setting goals and objectives, and reporting it properly to administrative areas and company's board.

As frequent decision makers, and strongly linked to the integration and activities' progress, the major responsibility for the project's success falls on the project managers' shoulders. If project is successful, lots of praise and thanks for the win will be received, but if unsuccessful, he will be the first to be blamed directly for the final result.

3. THE EARNED VALUE MANAGEMENT

According to Vargas (2011), the Earned Value Management (EVM) is a technique for measuring the projects' performance and progress through performance evaluation indicators. On an integrated system, the EVM can provide accurate future data identifying potential problems.

According SCHULTE cited in MORELLI (2007), a study done for Standliss Group on software projects, approximately 90% of them have failed, or by exceeding the budgeted costs or for finishing away from scheduled on planning. 33% were cancelled before being completed. Approximately 1/3 of all studied companies, varied types (small, medium or large), suffered from disproportionate costs growth between 150 and 200%. It is also estimated that US lost annually 1.45bi considering the not expected costs growth, beyond to non-compliance deadline. These data show that the techniques and methodologies are still not used properly, or have proven ineffective.

EVM is the comparison of three curves (BURKE cited in MORELLI, 2007) performance, defined as:

- **PV (Planned Value)** = **BCWS (Budgeted Cost of Work Scheduled)**. Responsible for evaluate the planned work costs to define the project baseline.

- **EV (Earned Value)** = **BCWP (Budgeted Cost of Work Performed)**. It is the measure of work performed until the measurement time.

- **AC (Actual Cost)** = **ACWP (Actual Cost of Work Performed)**. It is the actual cost of work performed until the measurement time.

According to baseline and well-defined analysis parameters, the Project Manager is able to measure the project performance, make future projections, quantify technical problems and set corrective action plans. Keeping the initial planning unchanged, he is able to manage the project integration by re-estimation due to the work done to date.

The picture below shows the main EVM parameters:
As presented on above picture are highlighted the budget baseline (BCWS), covering all project planned period, the actual costs incurred (ACWP) curve and the earned value until the measurement time (BCWP). On an ideal performance, the actual cost curve and the earned value curve should overlap the budget curve, representing a cost and schedule performances that are 100% the same as planned for the project.

3.1 Cost Performance Index

The CPI (Cost Performance Index) is the ratio between the earned value (BCWP) and the actual activity cost (ACWP) at the measurement time, as represented at Equation (1), below:

\[
CPI = \frac{BCWP}{ACWP} \tag{1}
\]

For example, if IDC result is 0.75, it means that for every $1 capital consumed only $0.75 was converted physically in product or service. The loss, therefore, is $0.25 per each $1 spent.

So, it can be said that an IDC equal to 1 means that the amount spent in the activity was completely earned (the activity is within budget). If the CPI is less than 1, the project is spending more than planned (indicates possible additional cost until project’s final). And, if CPI is greater than 1, the project is costing less than planned budget.
3.2 Schedule Performance Index

The SPI (Schedule Performance Index) is the ratio between the earned value (BCWP) and the planned value (BCWS) on a defined measurement date.

\[
SPI = \frac{BCWP}{BCWS}\quad (2)
\]

Analysing the same example, an SPI of 0.75 indicates that 75% of budget time has been converted to work. This results in a loss of 25% on the available time.

In summary, a SPI equal to 1 indicates that the planned value was integrally added to the performance. If the SPI is less than 1, the project is delayed. However, if the IDP is above 1, the project is schedule ahead.

3.3 Variance At Completion

The VAC (Variation At Completion) is the difference between budget cost (Budget At Completion – BAC) and the Estimated Cost At Completion (EAC), according to Equations (3) and (4) below:

\[
EAC = AC + \frac{(BAC - EV)}{CPI}\quad (3)
\]

\[
VAC = BAC - EAC\quad (4)
\]

3.4 Forecast Time Variance

A FTV (Forecast Time Variance or Delay At Completion – DAC) is the difference between the new forecast project finish (Time At Completion – TAC) and the scheduled project finish (Planned At Completion – PAC), according to Equations (5) and (6) below:

\[
TAC = \frac{PAC}{SPI}\quad (5)
\]

\[
VFP = TAC - PAC\quad (6)
\]
3.5 Measurement Structure

3.5.1 BASIC REQUIREMENTS

The EVM use requires an appropriately project design, due to applicate this tool. The first step is the baseline construction.

This baseline serves as a project guide, able to provide the reference points from which the project actual progress will be checked. The baseline is composed by the best tasks duration estimates, their start and end dates, costs and any other variables the project manager wants to monitor. Fleming & Koppelman cited on Couri (2006) suggest some key requirements to ensure efficient work using the earned value technique:

1. Project Scope Definition – a well-defined scope, describing all work to be done at Project in their respective phases;

2. Work Breakdown Structure (WBS) – all scope to be done should be represented on a WBS, where its lowest level represents the activity that will be completed and by whom. The WBS should be broken until an ideal level to allow the deliverables management. Nowadays, literature recommends a broken WBS until four levels;

3. WBS dictionary – document that defines what should be done on each work package (lowest WBS level). This document symbolizes a scope execution script of each project item.

4. Percent Work Complete – capacity to measure the progress percent anytime at the Project. It represents an effective and updated measurement system, able to measure the financial and physical project progress.

3.5.2 MEASUREMENT METHODS

According to Couri (2006), the work complete measurement technique to be used should be defined during the project planning phase. The technique should be based on three attributes: the activity duration, if the activity is repetitive or not, and the tangibility of the work product from the activity. These attributes relate to the work quantification or the physical progress.

Performance measurement should be carried out periodically, and can be performed according to the following methods (Couri, 2006):

- Fixed Formula - method that divides the work into two parts and that together complete 100% of the work. The most commonly used formulas are 25/75, 50/50 and 75/25;
Percent complete - this is the most used method in the project management world. It consists on assign a complete percentage to the activity, but you must follow some measurement parameters and not being subjective. Ex.:

Measurement: 15m³ digging run  
Total planned: 100m³ excavation  
Then, percent complete = 15%

Then, this activity percent multiplied by the total cost represents the budget portion already executed, and the physical and financial schedule as a consequence;

Project milestones with tangible results - this technique break the work to be performed in fractions, where each one is observed through a completed milestone. Thereafter, for each lowest milestone completed, a weighted value is assigned;

Combined complete percent and project milestones - on this method, each event or milestone within the activity is a percent complete. Then, this technique establishes a more accurate work complete measure by removing the subjectivity on determining the percent complete analyzing any tangible result;

Equivalent units - this technique subdivides the work or activity in equivalent measurement units and is used for measuring produced or performed units within a cost parameter. This technique is typically used in projects with repetitive activities.

The measurement technique to be used should be determined by the organization responsible for project execution. There is not “the” best technique, ie, the recommendation is to use some different measurement methods, depending on each activity to be performed.

4. CASE

4.1 Company Description

The corporation to be analyzed is an engineering design company, present on national and international market from 25 (twenty-five) years, based on Rio de Janeiro and that has three other offices in Brazil: São Paulo, Belo Horizonte and Salvador.

At the end of 2014’s, the company had around 400 employees, composed on its highest part by engineers and technicians, in addition to architects, administrators and system analysts. Beyond that, depending on demand, the company could hire outsourcing services.

Due to their experience years on the market, the company was being specialized and promoting training and specialization for their employees, also their management staff, by fostering seminars, workshops and specialized courses participation, like MBA in company, for example. Their offices are ISO 9001, ISO 14000 and OHSAS 18000 (the latter, only the headquarters building) certified and have many internal processes, constantly revisited according to PMBOK good practices.
4.2. Project Characteristics

In order to elaborate this case, it was selected a major port project (for now referred as XPTO project), from the company in question, whose client is a major Oil & Gas segment player, one of the largest oil companies in the world.

The XPTO project deadline was 6 months after contract signature, and its total budget was estimated on BRL 3,038,368.11.

4.2.1 PROJECT SCOPE AND BUDGET

According to PMBOK good practices, the project manager brake the WBS in 5 (five) control levels, where the lowest level represents a work package with well-defined scope, budget and deadlines, allowing monitoring and adjustments when necessary.

The picture below represents XPTO scope, designed on WBS Chart Pro® program:

As previously described, the project baseline costs is its total budget, what means the total resources planned to be spent over the project execution. The total estimated for XPTO project is BRL 3,038,368.11.

The Figure 6 below represents the budget costs around the project duration, describing the forecast accumulated expenses and, on Table 1, the WBS representing each work package budget percent, comparing to total XPTO budget.
According to data above makes it clear that engineering (on Executive Project phase) is the most expressive analyzing the planned costs, in other words is the work package that the project manager should concentrate his management efforts to keep the triple scope, schedule and budget under control.
4.2.2 Application

Due to its experience on execution and project management, the company established internal procedures in order to measure each work package physical progress. Each project is single and has variable scope but, after deliverables definition, the PM team is able to estimate the work packages and establish metrics to measure their evolution.

Considering the engineering projects based on documents issue (Data Sheets, Material Requisition, Material Take-Off, P&ID and general Drawings for example), the physical evolution is measured analyzing their elaboration status on company global electronical document platform, the local where all documents are stored for registration and version control. As far as each document move forward on the platform (Elaboration – Verification – Approval – Quality Analysis – Issue to Final Client), it is possible to measure each work package progress.

On this way, now the Project Physical Progress is going to be analyzed around its 6 execution months, in addition to its performance indexes.

4.2.2.1 Progress Analysis – Month 1

Due to the extremely tight schedule required in major engineering projects, many times Coordination and Planning teams do not have enough time to control customer requirements, perform project planning, subdivide the WBS, define the deliverables, set goals for teams and, in parallel, generate panels to be monitored by corporation’s board. Moreover, this is the stage in which the engineering disciplines spend more time studying the scope and solutions to be adopted throughout the project.

Therefore, on the first execution month, just a few deliverables was concluded, as described on chart below:

Figure 7 – Progress Report – Month 1
Analyzing above chart, we can notice that project is performing on a significant delay, spending more than planned, as noticed according to table below:

**Table 2 – Performance Indexes – Month 1**

<table>
<thead>
<tr>
<th>MONTH 1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI</td>
<td>68%</td>
<td></td>
</tr>
<tr>
<td>SPI</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>SV</td>
<td>-66.822,06</td>
<td>CV</td>
</tr>
</tbody>
</table>

According to table above, the Schedule Variance is negative, so project is delayed compared to original schedule, and Cost Variance is also negative, so the Estimate At Completion (EAC) is higher than Budget At Completion (BAC). Considering its indexes, the EAC and the Time At Completion (TAC) are presented below:

\[
TAC = \frac{PAC}{IDP} = \frac{6 \text{ months}}{0.53} \quad (7)
\]

\[
EAC = AC + \frac{(BAC - EV)}{CPI} = 111.79 + \frac{3.038,37 - 75.49}{0.68} = \text{BRL 4,499.5 thousands} \quad (8)
\]

Then, the project is performing in order to double its final date, in addition to increase 48% its costs.

Despite that, the Coordination team is mature and knows that this scenario is hardly to be prolonged during the project execution, as the first month was used for team mobilization, meetings in order to clarify the scope and client expectations and project data collection. Besides, at the end of month, the Project Manager presented team the project results, showing the impacts and clarifying what are the board’s expectation and the project relevancy for the company.

### 4.2.2.2 Progress Analysis – Month 3

The next analyzed period is going to be the third month, in other words, when the project is approaching to half of its period execution.

According to Figure 8, it realizes a significant improvement on second month, when the earned value exceeds the planned, but whose reaction is not repeated on third.
In order to investigate the performance causes, the coordination team was informed that some team members were on vacation on that period and, with no reposition members, some goals were not achieved on third month.

Besides that, considering the new performance indexes, it is noticed that would not be necessary an action plan in order to achieve those goals, only a constant monitoring.

Table 3 – Performance Indexes – Month 3

<table>
<thead>
<tr>
<th></th>
<th>CPI</th>
<th>PV</th>
<th>SPI</th>
<th>AC</th>
<th>SV</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONTH 3</td>
<td>107%</td>
<td>1.092.838.64</td>
<td>99%</td>
<td>1.012.115.60</td>
<td>-8.141.23</td>
<td>72.581.82</td>
</tr>
</tbody>
</table>

TAC = 6 months  
EAC = BRL 2,835.06 thousands

After 50% of project total time the Time At Completion was recovered, so project is no longer delayed and, according to Cost Variance, it is indicated a probable cost saving on deliverable time.

4.2.2.3 Progress Analysis – Month 4

Considering a more relevant project period, when was consumed 67% of its total time, it is noticed a project slippage, presented on chart below:
Even still having a well costs performing, the project is presenting a delay scenario again, according to its SPI and a negative Schedule Variance. Analyzing the chart above, the project manager realized that he could not keep project under control just doing a monthly presentation to team, and needed to analyze the work performance information. It is known that a good engineering discipline performance can mask the poor performance from other, resulting in a long-term problem, in case of no investigation and root causes treatment.

Thus, planning team analyzed the budget consumption from each discipline and which is each contribution to final performance (according to Figure 10), and concluded that the overall performance was influenced mainly by Electrical and Piping disciplines, as can be noticed on Figure 11 and Figure 12.

**Table 4 – Performance Indexes – Month 4**

<table>
<thead>
<tr>
<th></th>
<th>MONTH 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI</td>
<td>111%</td>
</tr>
<tr>
<td>PV</td>
<td>1.846.148,27</td>
</tr>
<tr>
<td>SPI</td>
<td>86%</td>
</tr>
<tr>
<td>AC</td>
<td>1.440.379,16</td>
</tr>
<tr>
<td>SV</td>
<td>-251.005,01</td>
</tr>
<tr>
<td>CV</td>
<td>154.764,10</td>
</tr>
</tbody>
</table>

TAC = 7 months
EAC = BRL 2,743.58 thousands
Figure 10 – Engineering Performance – Month 4

Figure 11 – Electrical Performance – Month 4
In this way, in addition to monitoring each engineering discipline, the Visual Planning technique started to be applied in parallel to War Room concept on XPTO project: planning team is responsible for grouping the entire project scope and, counting with disciplines support, split the work packages and organizes them according to their predecessors activities. These packages are distributed on post-its grouped in temporal order along the room’s wall, according to their issue forecast and showing the percent complete, enabling a project progress macro view.

The Visual Planning meetings are attended by coordination and planning team, in addition to all engineering disciplines, in a weekly basis, in order to discuss the project evolution, monitoring the packages scheduled for that week and next, in addition to punch list and any points of attention that could exist. The meetings are on a stand-up basis and no longer than 20 minutes duration, in order to keep the objectivity.

In order to achieve the company’s aim, the whole functional managers team was involved, corroborating with this new practice. Also, on Electrical and Piping disciplines new resources was allocated on project, in order to recover the accumulated issues delay.

4.2.2.4 Progress Analysis – Month 5

When project is near than 85% of its total time, it is time to measure the effectivity of actions adopted on last month:
Those actions had an extremely positive effect on project, the Schedule Variance and Cost Variance are positive, the Actual Costs are less than Planned Value, and CPI/SPI are higher than 1. The disciplines that before had a negatively performance recovered their issues, resulting on an intense inclination at realized Earned Value, as can be noticed on charts below:

Table 5 – Performance Indexes – Month 5

<table>
<thead>
<tr>
<th>MONTH 5</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI</td>
<td>131%</td>
</tr>
<tr>
<td>PV</td>
<td>2,543,178.43</td>
</tr>
<tr>
<td>SPI</td>
<td>106%</td>
</tr>
<tr>
<td>AC</td>
<td>2,047,170.50</td>
</tr>
<tr>
<td>SV</td>
<td>142,531,07</td>
</tr>
<tr>
<td>CV</td>
<td>638,539,00</td>
</tr>
</tbody>
</table>
Figure 14 – Engineering Performance – Month 5

Figure 15 – Electrical Performance – Month 5
Considering the indexes improvement in a moment that project is nearing the end, the new scenario shows an advance on scheduled final date and a 31% budget saving.

4.2.2.5 Progress Analysis – Month 6

The project was concluded 6 months after contract signature, issuing the last documents on limit date and presented an excellent financial result, as reported below:
According to Table 6, at project conclusion the Cost Variance was positive on 28%, representing a BRL 657 thousands saving, compared with Planned Value, improving the final project margin.

4.2.2.6 Comments

The split on work packages, the BCWS curve confection and the TAC / EAC estimative according to indexes parameters, provide a considerable increase on the amount of available information and the analysis of quality to be performed. Analyzing each main project activity, the Project Manager has a better diagnosis and control over their progress. He also has more security on decision taking, choosing the best corrective actions and making future projections.

It is also important to remember that these indexes behavior was influenced by a numerous corrective actions took throughout the project. Without these actions, those indexes would present a degraded and unstable behavior. For example, job leaders were appointed for each engineering discipline and given the responsibility to control their work packages, not only in terms of scope, but also in terms of time, and especially now, costs.

5 CONCLUSIONS

The engineering field has always been pioneer on application and adoption of project management methodology concepts. On the current market situation, different business lines realized this management technique benefits. The IT and Telecommunications fields were Brazilian leaders on these concepts implementation. Nowadays, the EVM concept is substantially applied on IT projects, due to high qualified labor force, what does not occur with the same intensity in other activity areas due to do not have an homogenous environment (Couri, 2006).

On this present study a bibliographic research about projects management and earned value analysis was made, presenting the concepts and analyzing all knowledge areas. A study of earned value management was done, describing concepts, formulas, performance measures and indexes, in addition to costs and time estimates. At the end, a case was presented, using the project management methodology applied on an engineering company. On this study, the earned value technique was applied on project performance management in order to verify the project quality and technical capacity to generate future projections.
The Earned Value Analysis is a tool able to consolidate some project information using a single unity (usually money). It is very efficient for bringing a macro projects view and, as a consequence, very used on client’s and board’s reports. However, this characteristic is not enough to be used as a control tool by Project Manager. Considering major and complex projects, for example, if EVA was used only to analyze the entire project, it is difficult to obtain an accurate and reliable diagnosis, after all, the good performance of one project item can mask the poor performance of another, in addition to having no indication of where is the real project performance problem.

Considering the project lessons learned it can be concluded that the generated forecasts on measurement times cannot be used as a single reference to project redesign, or to redefine its baseline. For this, it is necessary to review the project remaining activities, checking possible past and future deviations, such as employees efficiency, signed contracts, issued documents and resources to be used management.

Analyzing the generated panel, it can be noticed that there are pending data in order to monitoring the project performance and ask for improvements to each engineering team responsible. Until fourth month, the root deviation causes were not still identified, those were resulting on cumulated costs higher than earned value.

In addition to engineering job leaders nomination, CPI and SPI indexes should be measured and analyzed by each discipline, expressing an higher control level, where each discipline performance could be kept under control. Taking these results, the Project Manager is able to do a detailed analysis of each performance that are presenting deviation, searching for root causes and performing a Recovery Plan. The project indexes should be presented on a monitoring panel, near to Visual Planning, displayed to entire team, promoting a global engagement with project results.

6 REFERENCES
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The Model of Multiple and Parallel Runtime Trend Measurement and Prediction of Schedule Activities as a Function of Project Cost Control

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ABSTRACT

Numerous studies by multiple authors indicate that cost and schedule overruns are quite frequent in construction projects and global in nature. They are not a product of a single or few catastrophic events, but are result of a number of small disruptions and delays in everyday life of a construction site. Earned Value management, as most widespread method of project performance and progress measurement, failed to control cost and schedule overruns effectively. Study by Walt Lipke introduced a complementary method of Earned Schedule to correct some of the anomalies of Schedule Performance Index for projects that are already late.

EVM is based on financial data as common denominator to evaluate project progress, giving the project owner a broad picture of project health. This data does not help the contractor to contain the cost of construction within planned value, because: a) the financial data is gathered after the fact and represent a post-mortem analysis; b) most evaluation is based on human perception of percentage of completion which tends to be overenthusiastic and c) measuring quantity of tender item units does not give the information about actual constructor resources consumed. All of this prevents the constructor to intervene in the construction process in time to avoid delays and extra costs.

This paper proposes a model of multiple and parallel runtime trend measurement and prediction of schedule activities, as a function of project cost control. Each activity has a different critical resource whose consumption is nonlinear and governs the duration and hence the cost of the activity. The site administrator logs daily resource consumption in the Site Daily Log. This data is compared to the planned consumption timeline of the critical resource in each activity, detecting anomalies that might lead to cost or schedule overruns. The model describes a continuous automated runtime alert system that is integrated into everyday activities. The paper further discusses the implementation of the model in the Carpio-ERP information system.

Keywords: project cost control, cost overrun, schedule overrun detection, schedule measurement
1 Introduction

Construction projects show poor performance for decades. Cost and schedule overruns are quite common and studies have shown (Banaitiene and Banaitis, 2012) that risk of cost overrun is one of the most important risks in construction industry, classified as high and frequent.

Study done by Flyvbjerg et al. (2004) focused on the cost performance in transport infrastructure projects. The sample used was large, 258 projects in 20 nations (America, Europe, Japan and 3rd countries) worth approximately US$90 billion. The study showed that cost overrun occurs in almost nine out of 10 projects (86%). On average the costs were 28% higher than the forecast. Geographically, cost escalation in Europe was on average 25.7% against 23.6% in North America. In other geographical areas, the average cost escalation was 64.6% but the sample was rather small (16 projects). Analysis of cost escalation over time based on the date of completion led to conclusion that the cost performance has not improved over time. The cost overruns are in the same order of magnitude as it was 10, 30 or 70 years ago. The cost overruns, however, were not caused by some specific catastrophic event, but by numerous small delays and disruptions which were undetectable until their cumulative effect became significant.

A study of performance of cost overruns in transportation construction projects was led by Ahmed et al. (2003) for Florida Department of Transportation (FDOT) and showed interesting results. The purpose of the study was to understand to what extent are construction cost overruns avoidable and what actions can be taken to minimize the cost overruns and improve accountability for these problems. They performed an analysis of 102 projects with initial budget of US$ 302.7 million. It was found that the total cost overrun was US$ 28.6 million (a 9.5% of the budget) with more than half of those (US$ 15.6 of the budget) were classified as avoidable costs. About US$ 4.2 million (1.4% of the budget) in avoidable cost overruns represented wasted money. The responsibility for cost overruns was found to be shared among consultants, third parties and FDOT staff.

Cost increase is not only due to visible schedule overruns. Projects that seem to be finished on time, upon analysis may show unwarranted cost overruns.

A Stanford University Workshop (O’Brien, 1999) there was mention of two instances where resource availability (capacity constraints) and poor site conditions incurred real costs and limits on subcontractors and suppliers, bringing the Supply Chain Management as a significant factor of project cost overrun.

The example of Durand Centre, a US$150 million shopping mall project built in London was completed on time and placed second in a national project manager competition. But, there was a delay to steel fabrication that resulted in a six-week delay to steel erection on-site. The delay was not anticipated and did not become apparent until it occurred on-site. The contractor ordered acceleration of work at the cost of £231 thousand. Although on time, the project has shown cost overrun due to disruption of supply chain.

The other example is the Buchhaugen project which utilized a Just-In-Time style delivery system, a rolling three-week unit reorder, with 3 week lead time for the supplier to prepare the lot for delivery. In practice, the project management had great difficulty to predict the demand, resulting in more than half units deviations from the planned three week order period. Those disruptions resulted in difficult quantifying
saving in production lines, and a cost increase in at least one subcontractor.

It is no surprise that a lot of effort was put into development of tools that would help construction project management to keep project progress on time and within the budget. With new software tools it became clear that data collection became one of the major obstacles in obtaining meaningful data. On the other hand, Radujković et al. (2012) distinguish data overload to be one of the main reasons for project control failure. Inconsistent computer systems with unrelated flows of information cause miscommunication among the shareholders. Different computer segments need to work in unison to allow effective planning and project control.

2 Traditional Schedule Monitoring

The most widespread tool to monitor and control construction projects is Earned Value Management (EVM), a method that integrates cost, schedule and scope to give insights into performance and health of construction project. Normalized unit of measure is not time, but rather cost (money) and the method compares uses work units to calculate the value of planned work in time (Budgeted Cost of Work Scheduled – BCWS), the “earned” value in the same period (Budgeted Cost of Work Performed – BCWP) and actual cost (Actual Cost of Work Performed – ACWP). Schedule variance gives information whether the project is ahead or behind the schedule. Cost variance gives information whether the project is under budget or over budget. Schedule Performance Index (SPI) and Cost Performance Index (CPI) are ratios and indicate performance of the project. Those parameters are used to forecast the cost at the end of the project and time to complete the job.

Such a project management system, considered excellent for decades, shows some disappointing anomalies. Lipke (2011) indicated that traditional EVM performance indicators, CPI and SPI fail in projects that are late, which happens in almost 80% of cases. At the completion of a project which is behind schedule, Schedule Variance (SV) is equal to zero, and the Schedule Performance Index (SPI) equals unity. We know the project completed late, yet the indicator values say the project has had perfect schedule performance. Schedule indicators fail to provide good information over the final third of the project and they break completely if the project is executing past its planned completion date. This has special importance to construction projects as the S-curve shows that the resource consumption is more intense towards the last third of the project. He introduced the concept of Earned Schedule to compensate for late projects anomalies. The idea is analogous to EVM, but instead of using cost to measure performance, time is used. The significance of using the Earned Schedule concept is that the associated schedule indicators behave appropriately throughout project duration.

Based on experience, Lucas (2008) argues ten reasons why EVM does not function in real construction projects:

- no documented requirements
- incomplete requirements
- WBS not used or not accepted
- WBS incomplete

...
• plan not integrated (WBS-Schedule-Budget)
• schedule and/or budget incorrect
• change management not used or ineffective
• cost collection system inadequate
• incorrect progress
• management influence and/or control

Frequent practice in construction is to report work performed in percentage of completion relying on personnel or supervisor opinion, which is often overoptimistic and subjective. Malmendier and Tate (2005) established a relation between managerial overconfidence and sub-optimal corporate investment decision. This holds true on all managerial levels, which may lead to subjective, over-optimistic estimates about goal achievement.

If the cost parameter ACWP is derived from units of work performed, in most cases, it will be tainted, because it will not include rework, corrections, or other actual work that was not planned before.

On the other hand, if the costs are calculated based on actual invoices and other documents, the result of EVA will be even worse, because of the delay between the actual event and visibility of the document. A global study (Oracle, 2011) of 1500 organizations revealed that on average, financial data used for decision-making is 4.2 month old, although 28% of the managers do not even know the age of the data they use. The study further shows that it takes 1.7 months for finance managers to be made aware of company or market changes and 16% are never officially informed at all.

All of the above suggest that project progress monitoring has to be based on technical performance which should be used to render the values to be used in EVA, not the other way around. Regardless of the budget, there are technical constraints that need to be taken into consideration to evaluate the feasibility of the time to perform the work. Adherence to plan should be enforced by technical performance, because technical performance was used to estimate the cost and financial dynamics during bidding phase. If technical measures are used to enforce adherence to planned schedule, it is highly probable that the project will finish on time and on budget. The other way around, history teaches, is seldom true.

3 Measuring Activity Progress

The flow of any activity is governed by the resources that are used to compete it. The estimated duration of the activity should not be guesswork. The capacity of available resources will restrict maximum progress speed. In some cases, the actual progress will be slower due to relations to other activities and resources will be underutilized. If possible, such resources should be shared between activities introducing parallelism into the schedule and lowering construction costs. The resources used in the activity should ideally be identical to the resources used in unit cost estimation during the bidding phase. Broad scheduling should be part of the bidding phase so that plausible quantities of personnel and equipment can be estimated and minimum bid price calculated. Total resource quantities from unit cost estimate across the project should correspond to the totals used in the schedule.
In traditional schedule monitoring it is easy to calculate the planned value and earned value, as they can be derived from units of work completed. The actual cost, however, has to be calculated from contractors accounting, it is shifted in time rendering the project health assessment faulty. Lucas (2008) mentioned inadequate cost collection system as one of the top ten reasons why Earned Value Analysis doesn’t work. He stated that cost systems have limitations because they show only invoices received and/or paid. Any work that is contracted and any purchased items will have invoices that typically lag a month or more from the actual event. But this lag is not the only problem. Each invoice does not lag an equal amount of time, so at any given moment the accuracy of actual cost assessment is misleading.

The time anomaly in actual cost assessment is extended to other internal documentation. In an actual audit that the author has led in 2006 in a large municipal road maintenance company, the inventory documentation was lagging on average 28 days, which is much better than the Oracle report states. Although the Accounting department did take only three days to register the documents, some of them were 54 days behind the actual event, which introduces further inaccuracies into actual cost assessment.

Activity progress assessment anomalies based on budgeting values can be remedied by evaluating the progress on resource consumption. Consider a simplified activity of 16,000 m³ topsoil excavation. Typically one would use excavators (or bulldozers), loaders and trucks, operators and drivers and some auxiliary workers. If the excavator takes about six minutes to remove one m³ of soil, it would remove 10 m³ per hour and it would take 1,600 hours to complete the task. If in a 10 hour workday the crew achieved 8 effective work hours, the activity would take 200 days. If a second operator (and a second crew) could be secured, two shifts could be put into operation and the activity finished in 100 days. In this simplified view it is evident that the duration of the activity is governed by excavators. If we engaged more trucks or more loaders, the activity would still take 100 days with one excavator working in two shifts. The log of excavator work hours is mandatory for the operator, and is verified by the superintendent (foreman or other administrative personnel) in the Site Daily Log against the resting hours, as those values are the base for operator’s payroll. If there are 1,000 excavator work hours registered in the Site Daily Log, we could be quite certain that the activity is 62.5 % complete regardless of the state of the budget. We would also know that it will take 37.5 days to complete the task. If the activity was at day 70 it would be obvious that it would be 7.5 days late if the work intensity is maintained. A common practice in such cases is to increase the intensity of work so that the deadline would be met, without regard to increased costs that might erase the profit, as the Durand Centre study shows.

If excavator is chosen as the critical resource for topsoil excavation, all other resources in the activity would be spanned over 100 days. This may lead to floating resources during the day, which might be an opportunity to engage them in another activity. However, if there are not enough trucks (or drivers) to remove all the soil, the excavator may be constrained to excavate at less than full speed. In that case, the calculation may show that the activity cannot be finished in less then, for example, 105 days, rendering the trucks as the critical resource. Instead of work hours as a measure unit, we would use m³ transported or, if all the trucks were the same, the number of tours needed to complete the activity.

The model encourages resource enumeration to calculate the plausible duration of the activity. Any resource can be selected as critical, the one that governs the activity progress. Naming the resource as critical does not imply that the activity is on the critical path, just that the consumption of this resource gov-
erns the duration of this particular activity. Resource consumption, logged in the Site Daily Log, should be linked to the activity so that progress can be evaluated at any point in time. The duration of the activities that consume no resources is estimated in number of days and their progress updated manually as percentage of completion.

In the simplified example above, it was assumed that the daily consumption of the resource was linear, that the excavator was used sixteen hours each day. That may be true for highly repetitive activities but generally is not the case. Depending on technology used to drive the activity, the resource consumption over the activity duration may fluctuate. It is often the case that at the beginning of the activity, the resource consumption is low, and is accelerated towards the end of the activity. In most cases, the graph of resource consumption over time is not a flat line, but rather a curve whose shape describes the dynamics of the activity. The model allows the curve to be defined for any activity or group of activities and allow resource dynamics planning for the duration of the activity. Recorded quantities of consumed resource in the Site Daily Log should follow this curve, asserting the health of the activity progress. The resource consumption curve need not be defined for every activity as it can be inherited from the project or upper level group. If no curve is specified, then linear consumption is assumed.

But how would budget overrun be detected?

An activity is linked to a line item of the WBS and the unit cost calculation performed in the bidding phase. The planned value is derived from the resource unit prices that were used to estimate the linked line item. The activity may be linked to multiple WBS line items in which case the resource unit cost is averaged. The values of each resource for the duration of the activity are aggregated to render the planned value of the activity. The aggregated resource consumption logged in the Site Daily Log and WBS line item link render the actual cost of internal resources.

To avoid time anomalies in actual cost calculations, the Site Daily Log should be linked to procurement data. Purchase orders issued to material suppliers and subcontractors contain unit prices that in most cases will be the ones to appear on the invoice. When the supplier’s invoice arrives, Accounting will detect any differences and perform necessary corrections. When the resource consumption is logged in the Site Daily Log, the appropriate unit price is attached and aggregated values render actual cost that has no time distortion and is close to reality.

The Site Daily Log also records the quantities of work performed. Their volume is verified by the Measurement Log at the end of period. Their aggregated value renders earned value of work done. Calculating actual costs from work units built does not take into account actual hours and materials spent and can be misleading.

The link between Site Daily Log, schedule and WBS data enables the model to measure the activity progress and calculate values for Earned Value Analysis that are much closer to reality.

4 Measuring Schedule Progress

The flow of activities is organized into schedule most commonly in a form of a precedence diagram.
relationships between activities are defined so that float and critical path can be calculated. The traditional four types of relationship (start to start, start to finish, finish to start and finish to finish) can be extended with positive or negative time lags. However, in practice there are circumstances where standard relationship types are insufficient.

Hajdu (2015) introduced the Point to point precedence relationship which addresses the situation where two activities have to progress in sync. Consider ditch construction. Concrete encasement may begin after the excavation has started, but it must begin inside a time frame before the banks start collapsing. Although those two activities are progressing in parallel, the second activity may never progress quicker than excavation. They have to progress in sync from point to point.

Figure 1

The progress of each activity in the schedule is measured by consumption of a different critical resource, particular to that activity (Figure 1). The Site Daily Log contains records of resource consumption for multiple parallel activities and progress of any number of activities is monitored concurrently. Nonconformity to planned schedule or cost is detected at the activity level for all activities performed site wide. Each activity is monitored in different units of measure most suited for evaluate true progress. But
the most important fact is that data collection is not a separate process, but is achieved from everyday work of the foreman/superintendent/administrative personnel.

Any activity can be divided into sub-activities, more suitable to accurately define relationship between WBS estimating data, schedule and Site Daily Log. The activity tree structure can be of variable depth. The resource consumption curve can be defined at any level with the curve at sub-activity level having precedence over upper level making consumption curves customized for different critical resources. In most cases, the consumption of noncritical resources will follow the consumption curve of the critical resource. If the curve is defined, then daily (weekly, monthly) expected quantities are easily calculated and comparison with Site Daily Log entries easily achieved. This has a convenient side effect. As the non-critical activity resources are normalized to the duration of the activity governed by the critical resource, daily expected quantities for both critical and non-critical resources is calculated. This renders daily utilisation for any resource on any given day across multiple activities presenting view for parallelism or overload clashes.

Aggregated values will still give data for Earned Value Analysis, but it will not be clouded by activities that less important to project progress assessment. Concurrent monitoring of multiple activities will give clear indication of lack of adherence to planned progress.

5 Activity Trending

Activity progress monitoring via critical resource consumption records in the Site Daily Log opens some new possibilities. Suppose that in the above example, the excavator accomplished six working hours a day instead of eight for the past week. We would conclude that for some reason, the excavator is working at 75% of its capacity. If this condition continues, we could be pretty sure that time to finish will increase by 25%. It would be extremely helpful if authorized personnel could be alerted of such developments early so that mediating steps could be taken. Such anomalies in activities that are on the critical path are obviously of particular interest, but even activities that have float, might change the critical path if they are delayed enough.

Activity progress in construction fluctuates and further parameters should be designed to recognize the conditions that would trigger an alert. A few days of lower productivity does not mean that the activity performance is in jeopardy. In the above example, questions could be asked: should the alert be triggered after a week or two weeks of underperformance? Should the alert be triggered if the excavator worked 7 hours (-12.5%) or 6 hours (-25%)? Alert triggering conditions may be different for every activity in the schedule. If the trigger is not defined, it is inherited from the upper level of the schedule structure.

Such an alert system was described by Bacun (2016) in the context of operational risk status change detection. Trigger conditions are evaluated periodically and if set thresholds are met, an alert is generated. A trigger has the following elements:

The data source, the exposed values from an app, internet or simple data entry

Computational method that may be a simple expression (+-*/%) or an aggregate function (sum, count,
Threshold values

Trigger type and aggregate weight

This model can be simplified for detection of activity progress anomalies. The data source is the planned resource consumption curve of the activity. The actual resource consumption, logged in the Site Daily Log should closely follow the planned curve, within set thresholds. In that case we would know that activity progress is within acceptable limits regardless the everyday fluctuations. The simple way would be to test whether the actual critical resource consumption is within set thresholds drawn in green in Figure 2.

Regardless of EVA coefficients, at T3 point of time, the actual resource consumption would fall below the allowed threshold and we would know that the actual work achieved is prohibitively low resulting in possible delay. An alert should be triggered and the activity flagged.
But looking at the graph, we can see that at point T2 the actual values are exactly as planned (hours/m³/tours etc.). However, it is obvious that activity progress is going towards poor performance and that something should be done to remedy it. The anomaly could have been detected even earlier, at point T1. At that point, the actual resource consumption continued to fall although it was supposed to start rising. The actual quantity of resource consumed is still above the planned, it is well inside the set thresholds, there is no indication that something is wrong, except for the slope of the curve. The angle between planned consumption curve and actual consumption curve, marked as Phi in figure 2, show that trends are quite different. If a tangent line is drawn at point T1 on both planned and actual consumption curves, they should be more or less parallel. We might tolerate, for example, a 15 degrees angle between them to allow for fluctuations. If the angle is greater, an alert could be triggered and activity flagged or its status upgraded to a “watch” state.

6 Implementation of the Model Into CARPIO-ERP

Carpio-ERP is an enterprise wide resource planning system for construction industry, covering tasks from estimating to accounting. The development started in 1992 and its description exceeds the scope of this paper, so only practical circumstances pertinent to the model will be discussed here.

The line items of the Work Breakdown Structure are linked to schedule activities so that value of scheduled resources can be easily updated. The estimation procedures are based on unit costing. A line item can have any number of basic resources (materials, labour, equipment), subcontractors and assemblies (Figure 3). An assembly can contain any number of basic resources (materials, labour, equipment) and further assemblies. The depth of the assemblies is not limited and circular references are checked. When static resource calculation is performed, the total quantity of resources per line item is also calculated. If a schedule activity does not perform a line item in full, it is loaded with the quantity of resources needed to complete the task. The activity can also be loaded with resources specified in assemblies and adjusted manually.
The planned consumption curve is defined with sliders. The duration of the activity is divided in segments which are assigned a value via sliders. The rest of the points are interpolated. The area below the curve is normalized to the total quantity of critical resource in the activity so that exact quantity of planned consumption per day can be calculated at any given moment. At the same time, all other resources used in the activity are normalized to the activity duration and expected daily quantities are calculated. The consumption curve can be attached to a single activity or a group of activities.

The Site Daily Log record is linked both to one or multiple activities and the line items in the WBS. In practice, work gets done by teams, a group of people and machines, which, for a period of time, work the same activity. Data collection has always been a major problem. The system will let the administrator input a record for the whole team which greatly decreases data collection. Log entries for each resource will be generated and they can be manually adjusted. Team membership is recorded so that team performance across multiple activities, or even projects, can be monitored. Log entries for critical resources are used to update the scheduled activity progress.

Calculated planned consumption quantities across multiple activities for a particular interval (week, month) are used to generate the Request For Materials (RFM). The site is organized as a formal ware-
house and on material entrance the prices are taken either from purchase orders or internal documents, so they are always current. The warehouse output is generated from Site Daily Log records and they have to balance with material entrance. Material consumption is compared with calculated totals from WBS estimate.

7 Conclusion

Schedule and cost overruns have been a major problem in construction industry for a number of decades. Traditional tools to monitor project progress failed to remedy the situation. Earned Value management, as most widespread method of project performance and progress measurement, shows anomalies especially in projects that are already late. Collecting actual cost data based on accounting records proved unreliable due to different time delay for any particular document.

This paper describes a model of project progress monitoring that allows runtime trend detection and alert triggering. Multiple activities are monitored concurrently based on measurable resource consumption. Earned Value Analysis data is obtained with much greater accuracy.

The duration of each activity is calculated based on available resources and linked to WBS estimate. A critical resource is selected that governs the progress of the activity. The critical resource consumption does not have to be linear for the duration of the activity, it can be a curve of arbitrary shape. It is used to calculate daily planned values. The actual consumed quantities of the critical resource are logged in the Site Daily Log. The model compares how well the actual resource consumption follows the planned consumption curve using threshold values. Trends are detected by comparing slope angle of both curves at a single point in time. This will discover possible anomalies early in the progress of the activity and allow preventive measures. Exceeding set thresholds or allowed slope angle difference will trigger an alert and flag the activity to focus project manager's attention.

Finally, particularities of model's implementation in Carpio-ERP system are discussed.

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An Approach to the Identification of External Factors on the Project Complexity

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ABSTRACT

The evaluation and handling of complexity in the projects as a parameter of management has been of warm debate during past decade. Several approaches to administration of projects, deal with differentiation and interdependence of issues that affect the management of projects (complexity) with varied methodologies, models and factors (e.g. MODeST model, TOE framework, Crawford-Ishikura Factor, Complex Project Manager Competency Standards, among others). In this paper, we present a review of the evolution of the conceptualization of the complexity in projects, considering the factors that intervene in the same.

We propose a classification that differentiates the items in the domain of the management project and issues external to its management. We consider that the first one are addressed through the development of skills and competencies of the project manager, while those that are external are oriented to the organizational level and management of risks. This conceptual model contributes to the Project Management Office (PMO) in the identification of the main factors to intervene, in order to improve the management of projects. Although we address this proposal from observational approaches, its scope still requires validation mechanisms for its appropriate use and estimation of the uncertainties associated, in particular, to take into account the vast universe of problems to face.

Keywords: Project complexity; Complexity factors modelling; Structural equation modelling
1 INTRODUCTION

Different authors have written about the evaluation and project management complexity. E.g., Bennett (1991) said, “practitioners frequently describe their projects as simple or complex when they are discussing management issues. This indicates a practical acceptance that complexity makes a difference to the management of projects”. Nowadays, there are big projects that are developing with more interrelations, but they haven’t complete the delivery on time, proving that the traditional management methods of projects may not be appropriate. Thus, when observing the results, we may conclude that they are not applicable to the same sort of projects practices. Based on these observations, we consider that an alternative way to boarding the project management should be based on the theory of complexity, which emerged in the 90s (Strogatz, 2004)

Complexity is one of the characteristics of the project, regardless of the size and the uncertainty (Baccarini, 1996; Bubshait & Selen, 1992; Gidado, 1993). The project complexity is conditioned by factors such as the quantity projects elements, interdependence and the interrelation between them (Melles et al., 1990). Baccarini (1996) defines the project complexity as “compounds of many different interrelated parts” that can be approaching in differentiation and interdependencies terms. This definition applies to any relevant dimension for project management, as an organization, technology, environment, information, decision-making and systems. Same author indicates that is important to define the type of complexity, studying the two, and most common project management complexity: organizational complexity and technological complexity.

Williams (1999) points out about uncertainty as a new perspective on the definition project complexity. In addition, this author the number of interdependencies is not enough, and the nature of these interdependencies should be characterized. There is also a discussion about the differences between a complicated and a complex project (Maylor et al., 2008; Whitty and Maylor, 2009): One project is just complex when it has high uncertainties. On the contrary, the project is complicated.

The project managers classify the projects as simple or complex in the line of the number of interrelations or interactions; complicating the evaluation the effect of actions (Kauffman, 1993; Simon, 1969). Bosch Reveldt et al. (2012) demonstrate that organizational complexity is the one that most concerns. Vidal & Marle (2008) conducted a study with surveys of about 150 people, showing that 70% of the complexities of the projects are organizational.

In this work, we will discuss about project complexity based on a classification that differentiates items in the domain of the management project and the issues external to its management. A causal analysis is presented in the discussion section.

2. TYPES OF COMPLEXITY AND MECHANISMS OF MEASUREMENT

Several authors have characterized the project complexity in four dimensions: 1. Technological complexity, according to the objectives, the use methods, the scope of the system, the interdependence between tasks, equipment, technology or inputs (Turner and Cochrane, 1993; Shenhar and Dvir, 1996; Baccarini, 1996). 2. Organizational complexity: dividing by differentiation. (Hierarchical levels, organizational units
or tasks specialization) and by interdependence (interactions between organizational elements of the project), including relationships in terms of communication, responsibilities, decision making and other operational elements of the organization of the project (Baccarini, 1996). 3. Structural complexity: underlying structure of the project, framed in the organizational complexity of Baccarini (Williams, 1999). Including the variety of tasks and interdependencies levels (Williams, 1999; Williams, 2002; Remington and Pollack, 2007; de Souza et al, 2014). 4. Social Complexity: focused on complex projects as a dynamic and complex social network, as well as the social process of each project, and establishing the social network integrated (Yongkui and Yuji, 2009). From that dimensions, different authors have defined elements and influence variables that could help the organizations to identify and manage the complexity in projects (Table 1). Herrera at al. (2011) grouped those, ratings by affinities, calling technical dimension to the technical and structure complexity, and contextual dimension to the structure and social complexity.

Other authors have presented other similar proposals. E.g., Shenhar and Dvir (2007) propose a conceptual approach focusing on four aspects: novelty, technology, complexity and rhythm (defined as the limitations in time, the urgency in decision-making and reducing the life cycle of products and market).

2.1 MODeST model

Maylor et al. (2008) studied the perception of complexity in project management and they are the first generating an empirical study of multiples stages through a tool for classifying the complexity concepts. Along the study, they asked the main question: What does a complex project to manage? They identify and classify in dimensions of mission, organization, delivery, stakeholder or team (MODeST model) the different concepts identified by a manager and that makes a project complex. This study proposes an active management of complexity, that guides an individual reflection of behavior and organizational in projects. The research design is developed in two stages: (1). They realized study works in small groups in different kind of enterprises to establish the complexity topics in projects; (2.) A regional workshop was held on a big scale, with an attendance of 100 project managers.

Phase 1 was held for (1) developing and applying data collection allowing different complexity concepts, (2) proportionate a sensitization process to the perception of the effects of complexity in projects and (3) determine if the research allows obtaining a useful theory. Participants took the telecommunications field, the defense sector and a regional infrastructure provider. For the phase 2, there was an interview with 107 managers of the project in a professional association. As a result, they generate 160 concepts.

Authors concluded that the external interested had an impact in the result, expressing the interaction effect between the participant’s elements level and the methodology of project management (PMM) used, identifying that for each structural element there is a corresponding dynamic element (Maylor et al; 2008).

Maylor et al (2008) said that the work of the manager leading project in the perception of complexity indicated the answering of the question: What does a complex project to manage? One of the participants of the workshop realized the objective of the process, considering “not breaking down a project sufficiently” or “failure to recognize activity interdependencies” each manager is responsible for the activities.
Bosch-Rekveldt et al. (2011) found a difference between “Project complexity” and project management complexity, presenting complexity project management as a subset of the project complexity. The final purpose is to include all aspects of the project complexity. Despite the dynamic nature of the project complexity,

| Table 1 Previous research about project complexity. Types of project complexity. |
|---------------------------------|---------------------------------|---------------------------------|
| Technological complexity        | By                                | Number and diversity of inputs and/or outputs |
|       | differentiation                  | Number of differentiated actions to produce the product of a project |
|       |                                   | Number of specialities |
| Coletonal complexity             | By                                | Amount and complexity of organizational members |
|       | interdependency                  | Cognitive Complexity |
| Organizational complexity        | By                                | Between tasks |
|       | differentiation                  | Network of tasks |
|       |                                   | Between teams |
|       | By                                | Between different technologies |
|       | interdependency                  | Between inputs |
|       |                                   | Number of differentiated actions to produce the product of a project |
|       |                                   | Uncertainty in goals |
|       |                                   | Uncertainty in methods |
|       | Delivery (process, resources)    | Baccarini, (1998); Williams, (2002); Sinha et al. (2006); Geraldi and Adlbrecht (2007); Maylor et al's (2008); Vidal et al. (2011); Bosch-Rekveldt et al. (2011); de Souza et al, (2014); Christoph and Konrad (2014); Lu et al, (2015) |
| Structural Complexity            | Size: number of elements          | Williams, (1999); Williams, T. (2002); Remington and Pollack (2007); de Souza et al, (2014) |
| Social Complexity                | Interdependence of elements       |                                |
| Cultural Complexity              | Social                            | Remington and Pollack (2007); Geraldi and Adlbrecht (2007); Girmscheid and Brockmann (2008); Vidal and Marle, (2008); Yongkui and Yuji (2009); Herrera at al (2011) |
| Temporal Complexity              | Number of different cultures      |                                |
| Number of different languages    |                                  |                                |

2.2 TOE Framework
complexity during the different project phases, Bosch-Rekveldt et al. (2011) focus on the elements that contribute the complexity in the planning stage.

Brujin et al. (1996) mentioned by Bosch-Rekveldt et al. (2011), differentiate three complexity dimensions: technical, social, organizational and propose environmental or technical elements contributing the project complexity in big engineering projects. Basing on this, Bosch-Rekveldt et al. (2011) propose different categories, Technical (T), Organizational (O) and environmental (E), to comprehend the project complexity. Thus all the elements cited bibliographically are assigned to these categories.

TOEs frame allows evaluating the complexity of a planning project determining what area is hoping this complexity. This frame could support the risk evaluation in earlier phases. Moreover, it could help to make the right decisions like a required profile or the project equipment, or plan specified activities for risk management or interested management (Bosch-Rekveldt et al., 2011).

Bosch-Rekveldt et al. (2011) identify 50 elements that contribute to the project complexity and classify in three specific areas (Technical, organizational and environmental) and 14 subcategories (T: Objectives, the scope, tasks, experience and risk; O: size, resources, project equipment, trust, and risk; E: interest groups, location, market conditions and risk, Table 2).
<table>
<thead>
<tr>
<th>TOE</th>
<th>Sub-ordering</th>
<th>Elements defined</th>
</tr>
</thead>
<tbody>
<tr>
<td>T: Technical</td>
<td>Goals</td>
<td>Number of goals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goal alignment</td>
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<tr>
<td></td>
<td></td>
<td>Clarity of goals</td>
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<tr>
<td></td>
<td>Scope</td>
<td>Scope largeness</td>
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<tr>
<td></td>
<td></td>
<td>Uncertainties in scope</td>
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<tr>
<td></td>
<td>Tasks</td>
<td>Quality requirements</td>
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<td></td>
<td></td>
<td>Number of tasks</td>
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<td></td>
<td></td>
<td>Variety of tasks</td>
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<td></td>
<td></td>
<td>Dependencies between tasks</td>
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<tr>
<td></td>
<td></td>
<td>Uncertainty in methods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interrelations between technical Processes</td>
</tr>
<tr>
<td></td>
<td>Experience</td>
<td>Conflicting norms and standards</td>
</tr>
<tr>
<td></td>
<td>Risk</td>
<td>Newness of technology (world-wide) Did</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experience with technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technical risks</td>
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<tr>
<td>O: Organizational</td>
<td>Size</td>
<td>Project duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compatibility of different project management methods and tools</td>
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<tr>
<td></td>
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<td>Size in CAPEX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size in Engineering hours</td>
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<tr>
<td></td>
<td></td>
<td>Size of project team</td>
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<tr>
<td></td>
<td></td>
<td>Size of site area</td>
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<tr>
<td></td>
<td>Resources</td>
<td>Number of locations</td>
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<td></td>
<td></td>
<td>Project drive</td>
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<td></td>
<td></td>
<td>Resource and skills availability</td>
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<td></td>
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<td>Experience with parties involved</td>
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<td></td>
<td></td>
<td>HSSE awareness</td>
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<td></td>
<td></td>
<td>Interfaces between different disciplines</td>
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<td></td>
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<td>Number of financial resources</td>
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<td></td>
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<td>Contract types</td>
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<td>Project team</td>
<td>Number of different nationalities</td>
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<td>Number of different languages</td>
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<td></td>
<td></td>
<td>Cooperation JV partner</td>
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<td></td>
<td></td>
<td>Overlapping office hours</td>
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<td></td>
<td>Trust</td>
<td>Trust in project team</td>
</tr>
<tr>
<td></td>
<td>Risk</td>
<td>Trust in contractor</td>
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<tr>
<td>E: Environmental</td>
<td>Stakeholders</td>
<td>Number of stakeholders</td>
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<tr>
<td></td>
<td></td>
<td>Variety of stakeholders' perspectives</td>
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<td>Dependencies on other stakeholders</td>
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<td>Political influence</td>
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<td>Company internal support</td>
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<td>Required local content</td>
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<td></td>
<td>Location</td>
<td>Interference with existing site</td>
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<td></td>
<td></td>
<td>Weather conditions</td>
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<td></td>
<td></td>
<td>Remoteness of location</td>
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<td></td>
<td></td>
<td>Experience in the country</td>
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<tr>
<td></td>
<td>Market conditions</td>
<td>Internal strategic pressure Stability</td>
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<td></td>
<td></td>
<td>Stability project environment</td>
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<tr>
<td></td>
<td>Risk</td>
<td>Level of competition</td>
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<td></td>
<td></td>
<td>Risks from environment</td>
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</tbody>
</table>
Lu et al. (2015) introduce the dynamic of complexity nature under the perspective Task and Organization (TO), they propose a model measurement of complexity in a project through hidden work that reflected “emerging” effect of influencing factors on project complexity. Besides, through modelling the behaviour in a case study with 12 hypotheses in a work, they are linking the hidden workload with different attributes of the project, the team and the organization that executes it (Table 3).

Table 3 Influencing factors of project complexity from TO measure model. Source: Lu et al. (2015)

<table>
<thead>
<tr>
<th>Task complexity factors</th>
<th>Amount of task and complexity of task</th>
<th>Task complexity</th>
<th>Amount of organizational members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity of dependency among tasks</td>
<td>Pooled interdependence</td>
<td>Technological complexity&lt;br&gt;Goal uncertainty&lt;br&gt;Environmental complexity&lt;br&gt;Openness of elements&lt;br&gt;Dynamics of process&lt;br&gt;Resources availability&lt;br&gt;Information completeness</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organization complexity factors</th>
<th>Amount and complexity of organizational members</th>
<th>Complexity of organizational members</th>
<th>Leading ability&lt;br&gt;Technological ability&lt;br&gt;Coordination ability&lt;br&gt;Working background&lt;br&gt;Working experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity of organizational structure</td>
<td>Degree of centralization&lt;br&gt;Degree of formalization&lt;br&gt;Degree of matrixing</td>
<td>Degree of centralization&lt;br&gt;Degree of formalization&lt;br&gt;Degree of matrixing</td>
<td>Leading ability&lt;br&gt;Technological ability&lt;br&gt;Coordination ability&lt;br&gt;Working background&lt;br&gt;Working experience</td>
</tr>
</tbody>
</table>

2.3 CIFTER

With the purpose of identifying the right manager of a project, the Global Alliance for Project Performance Standards (GAPPS) use a tool called Crawford-Ishikura Factor Table for Evaluation Roles or CIFTER. The tool called like this because of the two main components GAPPS, allows identify the value of job skills according to the complexity of the projects.

There are seven factors CIFTER that defines the complexity in a project management. Each one has the same value. The factor is valued from 1 to 4 using a qualitative scale and the totalized value is (GAPPS; 2007):

1. **Stability of the overall project context**: Including the project life cycle, imprecision in methods degree, approaches, social economical groups, project context, indefinite phase deliverables, scope changes, project team, and uncertainty in the economic or political environment.

2. **Number of distinct disciplines, methods, or approaches involved in performing the project. The more disciplines involved more interrelations and more complexity. Including some aspects of “technical complexity”**
3. Magnitude of legal, social or environmental implications from performing the project: It includes the possible external impact of the project. It concerns the individuals and organizations outside the performing organization.

4. Overall expected financial impact (could be positive or negative) on the project’s stakeholders. Is considered the financial considerations related to the legal responsibility.

5. Strategic importance of the project to the organization or organizations involved.

6. Stakeholder cohesion regarding the characteristics of the product of the Project.

7. Number and variety of interfaces between the project and other organizational entities. It includes the interrelations between different organizations and different cultural conditions (GAPPS; 2007).

De Souza et al. (2014) identify the variables that affect the level of complexity and uncertainty and propose the project evaluation tools with a numerical scale measurement that support the process of the decision making. It separates the attributes of uncertainty and complexity variables, measuring these attributes separately and proposing an array of complexity and uncertainty. In addition, it proposes a measurement complexity and uncertainty scale in projects (low 10 points, average 130 points, and high 250 points), from which creates a matrix in a Cartesian plane (complexity in the horizontal axis - X, and uncertainty in the orderly - y).

3. COMPETENCE

The classifications previously made, suggest different frameworks for evaluating the complexity, because they characterize the level of complexity of a project, it also allows analyzing the factors that influence the effectiveness of actions (Whitty and Maylor, 2009) identifying the competencies of the leaderships.

In this work, were analysed 153 projects coming from a NOC, which were executed between 2010 and 2015. No projects were finished on time, neither on budget. Along each case, we performed a root-case analysis regarding the facts that affected the behaviour. Based on these analyses we identified 1,509 root-causes from 1,997 facts that were identified. These were classified by knowledge area and the appropriate level of influence for the management: 1. Domain leader (or project equipment); 2. Organization (organizational complexity); and 3. Environment (external influences to the organization).

We identified 147 root-caused corresponding to technical aspects. One by one were evaluated, to identify the uncertainty in early stages of the project and decreasing the level of impact. Thus, they were reclassified in the leader domain, if the development of a study could eliminate this uncertainty, or environment, if it corresponded to a level of technological complexity through differentiation, interdependence or innovation level, whose impact could not decrease the previous studies (Table 4).
Table 4 root causes classified by knowledge area and level of influence.

<table>
<thead>
<tr>
<th></th>
<th>Environment</th>
<th>Organization</th>
<th>Domain leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>240</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeholders</td>
<td>24</td>
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<td>Social</td>
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<tr>
<td>Procurement Management</td>
<td>178</td>
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<tr>
<td>Time</td>
<td>152</td>
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<tr>
<td>Process Projects</td>
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<tr>
<td>HSE</td>
<td>38</td>
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<td></td>
</tr>
<tr>
<td>Change Management</td>
<td>12</td>
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<tr>
<td>Scope</td>
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<td></td>
</tr>
<tr>
<td>Human Resources</td>
<td>177</td>
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<td></td>
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<tr>
<td>Shaping Equipment</td>
<td>157</td>
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<tr>
<td>Quality</td>
<td>59</td>
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</tr>
<tr>
<td>Costs</td>
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<td></td>
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<tr>
<td>Integration</td>
<td>21</td>
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<td></td>
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<tr>
<td>Operation</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change control</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical aspects</td>
<td>100</td>
<td></td>
<td>47</td>
</tr>
<tr>
<td>Others</td>
<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>312</td>
<td>525</td>
<td>628</td>
</tr>
</tbody>
</table>

The 42% root-causes are related to the organization domain, the 34% correspond to the project, and the 24% to the environment.

4. DISCUSSION AND CONCLUSIONS

Generally complexity classifications are used in organizations to have an integrated vision of the project that allows evaluating in many different levels: financial, uncertainty, impact and integration, also taking actions in order to reduce the complexity degree. In this way, to address technology issues, type of project, legal and regulatory framework, trade agreements, stakeholders, sort of innovation, etc. the level of complexity of the project can be identified by tools and techniques to facilitate project management and appoint a project leader with skills to sustain high performance in the management of complex projects (Whitty and Maylor, 2009).

This work aims to integrate the classification parameters in the levels of competence about the principal issues evaluated in previous works. Because of the activities that we characterized are the role of the management project leader, as well as the type of organization that executes the project, or the environment, this group may identify actions related to competence in order to decrease the level of complexity.
We found that 42% root-causes are related to the organization domain. This is consistent with the findings of Vidal & Marle (2008) and Bosch Reveldt et al. (2012), who identified that organizational complexity is the most impacting projects and the most concerning to the project leaders. Some of the causes are initially catalogued by organizational leaders, which explain the high percentage of organizational complexity shown in previous studies (Vidal & Marle, 2008; Reveldt Bosch et al, 2012.). However, after analyzing the facts, valuing the leader competences, we concluded that really belonged to the domain of the leader.

The 34% of the root-causes are associated to the leader domain. We identified projects with middle complexity that were assigned to project leaders with low experience in equipment management. In a company with a high vertical and horizontal differentiation, having leaders with little authority or level of seniority in projects with high interrelationships, it causes risks, than a leader with more experience may hand.

We detected a 24% of the root-causes related to the environment. This includes: social aspects, environmental, regulatory and physical security. This figure was increasing in recent years, because of the rules have changed, especially in the aspects of interaction with communities.

Classifying the project complexity aspects in the domain of leader, organization and environment, we may take actions to decrease the level of complexity. Thus, we believe that is important to control the impact of these factors in the results of an organization. In this work, we found that the problems observed during the project executing were materialized by the lack of competence or experience of the leader. However when the company finds that the project complexity is due to internal causes, it can hire competent project leaders. There are different standards and practices that give tools to the project leader and the organization to assess and manage the complexity of projects: Framework Cynefin, CIFTER, CII CII RR305-11 (Dao et al, 2016), among others.

The root-causes of organizational aspects include the lack of some of the success factors identified by Cooke-Davies (2002):

Maturity of an organisation’s processes for assigning ownership of risks (F2).

- Adequacy with which a visible risk register is maintained (F3)
- Adequacy of an up-to-date risk management plan (F4)
- Adequacy of documentation of organisational responsibilities on the project (F5).
- Maintain the integrity of the performance measurement baseline (F8)
- Portfolio- and programme management practices that allow the enterprise to resource fully a suite of projects that are thoughtfully and dynamically matched to the corporate strategy and business objectives (F10)

Those elements are presented because of the high differentiation organizational typical of NOC organizations and the functions of projects scattered in different functional areas. Because of the impact of costs in project results, in near future is necessary to make a benefit-cost study, with the purpose to identify, if an organizational change in the project function, would allow control the project results.
Given that, the study only integrates the complexity aspects, which no fulfil the costs and time target, we suggest for future researches, integrate in the evaluation, diverse projects coming from different industries, with the intention of contrasting other dimensions as: market, legislation, social relationships, project size, success factors in projects completed on time and cost, etc.

This study contributes to improve the knowledge of project complexity of the NOC analysed, and identify the main factors that affects the project management. However, the results should be well-interpreted due to validation lack of the proposal, but also due to it still requires validation mechanisms for the proper use, taking into account the specificity of every single project.

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‘mycareerpath’ – the Ultimate On-line CPD Tool

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He is a Past-Chairman of ICEC and the current Chairman of the ICEC Advisory Group. He is also a Past-President of the ACostE and the current Chairman of the ACostE Engineering Committee. He has over fifty years experience in the oil and gas and construction industry and has also been involved in the development and delivery of Cost Engineering education and training.

INTRODUCTION

In the not too distant future there will be a need, and a duty, for members of professional bodies to be able to demonstrate their Continuing Professional Development (CPD) to retain their membership, certification or registration. ICEC has a prescribed process for the accreditation of Cost Engineering, Quantity Surveying, Project Management and related Continuing Professional Development (CPD) and Speciality Certification Programs.

In the UK the Engineering Council (EngC) has developed the on-line tool ‘mycareerpath’ which is now being used by nearly thirty professional bodies, including the Association of Cost Engineers (ACostE), to enable their members to easily plan, record and demonstrate their CPD.

The beauty of this system is that it is like keeping a diary. It is structured so that you can package your CPD up in a report which you can then send for review to any relevant authority. Meaning the information has only to be put in once but can then be used as many times as required.

This paper introduces ‘mycareerpath’, discusses its’ structure and operation and then demonstrates how it complements the ICEC accreditation process.

What is CPD?

ICEC encourages member associations to establish a continuing program whose goal is the improvement of individual Cost Engineering, Quantity Surveying and Project Management skills and professional development.

The Engineering Council’s Policy Statement on Continuing Professional Development says ‘CPD is under-
stood across most professions as the systematic acquisition of knowledge and skills, and the development of personal qualities, to maintain and enhance professional competence.'

The Institution of Chemical Engineers says ‘CPD is the means by which professionals maintain, broaden and deepen their knowledge, skills and competency. It helps professionals develop the personal qualities required for their working lives. It is essential that you regularly devote time to your own professional development.’

The CPD Certification Service in the UK defines CPD as ‘the holistic commitment of professionals towards the enhancement of personal skills and proficiency throughout their careers.’

Continuing Professional Development is used to describe the learning activities professionals engage in to develop and enhance their abilities. It enables learning to become conscious and proactive, rather than passive and reactive.

CPD combines different methodologies to learning, such as training workshops, conferences and events, e-learning programmes, best practice techniques and ideas sharing, all focused for you to improve and have effective professional development.

**What is the purpose of CPD?**

To raise the professional standards and improve the practice of Cost Engineering, Quantity Surveying and Project Management by giving special recognition by their peers to those who, in fulfilling prescribed standards of performance and conduct, have demonstrated and maintained a high level of competence and ethical practices.

To identify, for employers, clients and the public, persons with a broad knowledge of, and capability to professionally apply, the principles of Cost Engineering, Quantity Surveying and Project Management.

Engaging in CPD activities ensures that both academic and practical qualifications do not become outdated or obsolete; allowing you to continually ‘up-skill’ or ‘re-skill’ yourself, regardless of occupation, age or educational level.

**Why is CPD Important?**

Undertaking CPD will help your understanding, knowledge and skills, regardless of your present capabilities, performance or seniority. It will enhance your career prospects in a rapidly changing job market, increasing your adaptability and offering you more employment flexibility. Employers will consider CPD as evidence of an individual’s investment in their own career development and may have their own processes and requirements in place. Therefore, striving to improve your professional knowledge, understanding and practice is beneficial to the profession, to your employer and to you.

CPD helps you to regularly focus on how you can become a more competent and effective professional. Training and learning increases your confidence and overall capability, and compliments your career as-
CPD enables you to adapt positively to changes in work/industry requirements. Planning CPD helps you to be more efficient with time, and recording your CPD properly provides evidence of your professional development (this can also be useful for supervision and appraisals).

CPD encourages a structured, practical and methodical approach to learning which helps employers across industries to keep key staff and develop the skills and knowledge in their organisations to maintain a sustainable and competitive advantage.

‘mycareerpath’ – what is it?

In the UK the Engineering Council (EngC) has developed the on-line tool ‘mycareerpath’. Owned and maintained by the Engineering Council the system is promoted and branded by the participating institutions. Currently nearly thirty UK Professional Engineering Institutions and Affiliates, including the Association of Cost Engineers (ACostE), are licensed to offer the system to their members.

‘mycareerpath’ is an online tool for engineers and technicians to plan, evaluate, record and demonstrate their CPD. Users can record activities and experience that contribute to their CPD and build up a body of evidence that can be updated, printed, and sent to colleagues or institutions for online review and comments. The system is mobile and tablet compatible, so records can be accessed and added to on-the-go.

‘mycareerpath’ is aligned with the UK Standard for Professional Engineering Competence (UK-SPEC) for Chartered Engineer (CEng), Incorporated Engineer (IEng), Engineering Technician (EngTech) and Information and Communication Technology Techniciations (ICTech). It is also aligned with other titles such as Chartered Physicist (CPhys), Chartered Environmentalist (CEnv) and Chartered Scientist (CSci), to provide one platform to suit all. It can be used as an Initial Professional Development (IPD) tool for tracking progress against these competence standards.

The system is like keeping a diary. It is structured so that you can package your CPD up in a report which you can then send for review to any relevant authority. Meaning the information has only to be put in once but thereafter can be used as many times as required.

‘mycareerpath’ – what is the institution’s role?

Although ‘mycareerpath’ is owned and maintained by the Engineering Council the system is promoted and branded by the participating institutions who are licensed to offer the system to their members. They publicise the system and provide support to their members, including a user guide. They also customise the look and feel of the system, manage the profiles (such as CEng, IEng, EngTech and ICTech) and provide feedback to the Engineering Council.

‘mycareerpath’ – how does it work?

Members access the system from their institution’s secure online ‘members area’.
Each member sets up an individual account, to hold their own information, and choses one or more profiles, such as CEng, IEng, EngTech, ICTech or even simply CPD.

The first section of the account enables each member to plan their own professional development - by entering the title of the proposed activity, the start and end dates, and the objectives of the activity.

The second section of the account enables each member to add evidence of the professional development undertaken - by entering the title of the activity undertaken, the start and end dates, the category (whether formal or informal), the benefits gained from the activity and the lessons learned. This section also enables each member to enter the number of CPD hours or points, if awarded, the name of the training provider, if relevant, and to upload any documents in support of the activity (such as a CPD certificate, a programme or proceedings).

At any stage the system is able to generate a report of both plans and activities for any determined time period. This report can then be sent for review when required. The system is also able to return any comments from the reviewer.

Each member only has to enter their own information once and thereafter it can be used as many times as required. They will always have complete control over it and they can add to it or delete it as and when they so wish.

**Conclusion**

As professionals we are always striving to keep our knowledge up to date and are keen to learn new things. This is CPD and we all do it, even though we may not specifically recognise it as such.

Successful annual reviews depend on the judging of performance against plans. This again is CPD.

In the not too distant future there will be a need, and a duty, for members of our professional bodies to be able to demonstrate their CPD to retain their membership, certification or registration. This is already a requirement in some other professions.

'mycareerpath' is a web based system which enables you to easily plan, record and demonstrate your CPD. It enables you to package your CPD up into a report which you can send for review to any relevant authority.

'mycareerpath' complies with the ICEC prescribed process for the accreditation of Cost Engineering, Quantity Surveying, Project Management and related Continuing Professional Development (CPD) and Speciality Certification Programs.

**References**

Factors that affect transaction costs of projects in Brazil

Samuel de Jesus Monteiro de Barros¹, Raphael Oliveira Albergarias Lopes², Eduardo Linhares Qualharini³

ABSTRACT

Purpose of this paper

Concern with the project costs is constant, especially when there is a relationship between contractor and contracted party. Deviations in costs can cause financial impact and can derail projects, as well as changes they cause in results and may reduce the success and perception of quality by contractors. Project costs are usually divided into costs of the project cycle and transaction. The aim of this study was to identify the factors that affect transaction costs in the Brazilian scene.

Design / methodology / approach

For this model, it was tested the “factors that affect transaction costs” developed by Li et al. (2013) and applied in US project managers. This model has used structural equation modeling in partial least squares as data analysis technique. Data collection was performed in the database of a large oil and gas company, project management students from prestigious business schools and qualified project managers, all of them from Brazil.
Findings and value

As result, it was observed the following factors that can minimize transaction costs: (i) predictability of project owner's behavior, (ii) predictability of contracted parties' behavior, (iii) project management efficiency and (iv) uncertainty on the transaction environment. As shown by Li et al. (2013), it cannot be disregarded as agents that affect transaction costs in Brazil, however, it is noticeable that elements such as predictability of project owner's behavior and uncertainty on the transaction environment are most relevant to the Brazilian manager than project management efficiency and predictability of contracted parties' behavior.

Originality / value of paper

This is a forefront study regarding the transaction cost analysis projects in Brazil context.

Conclusions

In Brazil, concerns of managers in relation to transaction costs in projects are much more focused on contracting issues and business environment than in relation to the contracted parties and their ability to efficiently manage the project.

Keywords: transaction costs; costs; partial least squares; project management.

1. INTRODUCTION

Time taken to determine costs and expenses of a project is significant, regardless of the type and nationality of the agents. This is because there is interest of all parties involved as to what will be done to maximize outcomes, seeking the best possible management at the lowest possible cost. Values that are affected by estimates and that in turn will be charged to the project contractor become project costs, according to Hillebrandt and Hughes (2000). However, it is not only the price shown for the realization of the project which should be regarded as actual cost of the project. Elements such as drafting contracts, organization of procurement, contract administration, among others, should be considered in the estimates, in order to achieve the best possible cost expectation. For Coase (1937), these costs are known as transaction costs.

Williamson (1975, 1981 and 1985) posits that organizations adhere to certain different formats each other in the pursuit of minimizing transaction costs on the part of economic agents. In an economic viewpoint, it is possible to determine that the assumptions underlying the theory of transaction costs are: (i) limited rationality of economic agents; and (ii) the opportunism present in the actions of economic agents.

Simon (1959, 1976 and 1979) shows strong statements that, most of the time, rationality is limited. So, it is possible to realize that because of the complexities and uncertainties of scenarios, added the inability to have full access to all the information and technical and behavioral skills, economic agents will be urged to establish contracts and parameters that attempt to cover the most known potential uncertainties. From this perspective, the choices are no longer data and become variables of the problem. Being
limited, rationality ultimately depend on the behavioral process of the agent decision-making, transferring the decision focus to a cognitive layer.

For Gaffard (1990), the main concern, because there is limited rationality, is related to find levels of choices, routines, scopes and time that meet acceptable levels of satisfaction without prejudice to the existing “certainty”.

According to Burlamaqui and Fagundes (1993), because of rationality limitation and dependence of the cognitive process of economic agents, anticipating events, predicting events and creation of previous corrective measures become quite complex, because it is not possible to predetermine future behavior of the agents. In order to reduce possible impacts, organizations end up applying assessments and controls by means of economic systems.

As opportunism, Williamson (1985) defines the pursuit of self-interest with guile, due to the knowledge of the existence of information asymmetries, what may give rise to moral risk and adverse selection. Thus, opportunism can be classified as manipulation or concealment of information or intentions, seeking to make profits that alter the initial setup of the contract.

The existence of asymmetry is a constant, as always one of the economic agents will own greater knowledge about information not available to the other participants in a transaction. This can occur because there is insufficient interest on the part owner of privileged information to behave efficiently.

It is possible to note that transaction costs present a significant behavioral bias, which is discussed in greater detail in the following sections of this paper. Thus, it was chosen to test the model presented by the study “factors that affect transaction costs in construction projects” from Li et al. (2013) in Brazil’s market.

Thus, the work is to assess whether (i) predictability of the project owner’s behavior, (ii) predictability of contracted parties’ behavior, (iii) efficiency in project management and (iv) uncertainties on the transaction environment are key factors to minimize transaction costs in projects.

For this purpose, a quantitative analysis was performed using structural equation modeling with partial least squares. The questionnaire was proposed for 1,500 professionals of large oil and gas company in Brazil and project management students, however, the sample consists of 235 respondents. This represents a 15% response rate.

As result, it was observed that the factors proposed by Li et al. (2013) does not have the same grip on the reduction of transaction costs in projects when treated in the Brazilian market. Thus, it can be observed that the existence of cultural difference could be one of the existing variables, unmapped in the original study.

The work is divided into 4 chapters in addition to this introductory chapter. Chapter 2 deals with in the theoretical basis and the transaction cost’s concepts in a behavioral vision and project vision. Chapter 3
describes the data processing methods. Chapter 4 presents the results obtained and the descriptive statistics of the sample. In Chapter 5 are found the discussions. In addition to these chapters, the last part presents the references used in this study.

2. TRANSACTION COSTS

In an economic approach, transaction costs provide a useful framework for analyzing inevitable differences of interest between parts of a project (Winch, 1989). To the economy, transaction costs assume the existing spent on a project, pre or post operating, in order to reduce the uncertainties in existing projects (Williamson, 1987).

Therefore, transaction costs are different from other production costs, considering that production costs are directly related to spending on the transformation of inputs, in the case of a project, in the making of the project itself; since transaction costs arise from an economic exchange in the pursuit of the lowest possible uncertainty (Williamson, 1987).

With the search to reduce uncertainties, contractors and contracted parties are seeking to maximize their results, incurring the lowest possible risk (Damodaran, 2010). Hence, it is possible to believe that, in order to reduce risks, existing agents in a project end up having higher expenses for transaction costs, which could lead to a higher cost to the project. So it is possible to determine that there is a transaction paradigm, which has received the attention of many scholars in various topics, such as Jobin (2008) focused on governance; Whittington (2008) focused on project delivery; Lai (2000) focused on subcontracts and Farajian (2010) focused on measurement of transaction costs.

It is noteworthy that most of the studies related to transaction costs is about theoretical aspects and has qualitative bias. Also, according to Li et al. (2013), it is possible to observe an absence of standard terminology within the disciplines that investigate and work over transaction costs.

Williamson (1985) defines how transaction costs incurred on the preparation of proposals, negotiation, construction contracts, governance and predecessor controls and post-project contracts. Additionally, Joskow (1985) considers that also should be considered as transaction costs those ones related to acquisition and processing of information, legal costs, mobilization and demobilization costs, expenses related to inefficiencies and costs associated with contract violations and penalties, as suggested by Rahman and Kumaraswamy (2002).

Three basic attributes define the transaction, in Williamson’s view (1985): frequency, uncertainty and specificity of the assets involved. To Pondé (1996), transaction costs are funds expenditures to plan, adapt and monitor the interactions between agents, thus ensuring that the contractual terms are satisfactorily performed for the parties involved.

As can be observed, theories about the definition of transaction costs have been evolving over time, eventually being considered by some authors a theory in an evolving process. Being an element still not 100% defined, much of the decision and the expenses involved in transaction costs can be directed to behavioral perspective, however, before seeking a less analytical perspective, there is a need to understand the types of costs addressed by this work.
Transaction costs considered in the study are divided into:

- **Pre-contractual transaction costs**: costs incurred prior to the transaction itself occur. At this stage, there are internal spending (project preparation) and external spending (consultancies and advisory services), according to Soliño and Gago dos Santos (2009). Among the most common expenses that make up this part, it is possible to list the costs related to project feasibility assessment, environmental impacts, bidding and document preparation, among others. For Whittington (2008) and Dudkin and Valila (2005), spending at this stage may vary between 0.4% and 8.8% of the contract value, depending on the negotiation.

- **Post-contractual transaction costs**: all costs incurred in the project, after signing the contract, but before its closure, which were not foreseen in its product cost structure (Williamson, 1985). These costs can be determined also by poor contractual adaptation, project course correction efforts and emergence of unanticipated events previously. Among the costs that make up this stage, it is possible to highlight the costs of litigation, which, according to Whittington (2008), may represent between 8% and 14% of the contract in the event of disputes and expenses with design and operations support.

Thus, the work, more behaviorally, concerns to analyze whether the (i) predictability of project owner’s behavior, (ii) predictability of contracted parties’ behavior, (iii) project management efficiency and (iv) uncertainties on transaction environment are key factors to minimize transaction costs in projects.

### 3. RESEARCH METHODOLOGY

This study adopts a quantitative approach. The data collection for the analysis was carried out from March to May, 2016, in the city of Rio de Janeiro, Brazil. Questionnaire was sent to 1,500 professionals of an oil and gas company of nationwide business and project management students, however, the sample is composed of 235 valid respondents. This means a rate of 15% of responses.

According to the theories presented in the paper, transaction costs come from the interrelation between behavioral factors, in most cases, and environmental factors. Therefore, by having a significant number of elements which has its origin in “behavior” and “perceptions”, it is suitable to work with latent variables, being the observed variables reflections from the constructs.

For this work, it was considered as latent variables, or determinant ones that influence the cost of the transaction: (i) predictability of project owner’s behavior, (ii) predictability of contracted parties’ behavior, (iii) project management efficiency and (iv) uncertainties on transaction environment. Thus, the hypothesis developed by Li et al. (2013), tested in this work, are:

- **H1**: Transaction costs (TC) are lower if the project owner’s behavior (POB) is predictable.
- **H2**: Transaction costs (TC) are lower if the contracted parties’ behavior (CPB) is predictable.
- **H3**: Transaction costs (TC) are higher if the uncertainties on transaction environment (UTE) are high.
- H4: Transaction costs (TC) are higher if the project management efficiency (PME) is high.

3.1 Data Collection Instrument

To test the hypothesis, it was used a structured questionnaire (in Portuguese, for Brazilian respondents), adapted from the questionnaire suggested by Li et al. (2013). The questionnaire was applied using online system, addressed solely to professionals from a Brazilian oil and gas company and graduate students in project management field.

Box 1 shows the set of observed variables, their constructs and acronyms, which were used 5 variables observed for the construct “uncertainty on the transaction environment”; 3 variables used for the construct “predictability of contracted parties’ behavior”; 3 variables used for the construct “predictability of owner’s behavior”; and 3 variables used for the construct “project management efficiency”. All variables were developed with answers in 5-points Likert scale, for which 5 means strongly agree and 1 means strongly disagree.
**Box 1 - observed variables and constructs**  
*Source: adapted from Li et al. (2013)*

<table>
<thead>
<tr>
<th>observed variable (OV)</th>
<th>acronym of (OV)</th>
<th>construct (C)</th>
<th>acronym of (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High project complexity increases uncertainty on the transaction environment, hence, increasing the cost of procurement.</td>
<td>UTE1</td>
<td>Uncertainty on the transaction environment</td>
<td>UTE</td>
</tr>
<tr>
<td>When the scope of a project is not well defined, initial drawings and specifications are likely to change, prompting many claims and change orders that, in turn, increase transaction costs.</td>
<td>UTE2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incomplete plans and specifications may increase the number of disagreements and disputes, hence, increasing transaction costs.</td>
<td>UTE3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low bidders may create a less competitive procurement process, but may reduce transaction costs.</td>
<td>UTE4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incentive / disincentive clauses may motivate the contractor to minimize project duration, but may cause an increase in transaction costs.</td>
<td>UTE5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspicion of unbalanced bidding, cheating, and collusion may cause uncertainty in the bidding environment, and may cause the owner’s overall project cost to get higher, but it is hard to detect unbalancing and collusion, and may generate contentious change orders, all contributing to higher transaction costs.</td>
<td>CPB1</td>
<td>Contracted parties’ behavior</td>
<td>CPB</td>
</tr>
<tr>
<td>Good relationship with previous clients may enhance cooperation and trust between owners and contractors, and create stability in the contracted parties’ behavior, hence, lowering transaction costs.</td>
<td>CPB2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequent material substitutions may cause frequent claims, fluctuations in product costs, and higher transaction costs.</td>
<td>CPB3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A smooth relationship between parties may enhance cooperation, reduce disagreements, and allow for easy resolution of conflicts, creating stability in the owner’s behavior, and, hence, reducing transaction costs.</td>
<td>POB1</td>
<td>Project owner’s behavior</td>
<td>POB</td>
</tr>
<tr>
<td>Organizational learning may be effective if the lessons learned from completed projects are kept in the organizational memory and used in future projects, hence promoting stability in the owner’s behavior, and reduction of transaction costs.</td>
<td>POB2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A poorly defined scope and incomplete plans and specifications may increase the number of post-contract changes by owners, hence, increasing uncertainty in the owner’s behavior and increasing transaction costs.</td>
<td>POB3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A smooth relationship between parties may enhance cooperation, reduce disagreements, and allow for easy resolution of conflicts, creating stability in the owner’s behavior, and, hence, reducing transaction costs.</td>
<td>POB1</td>
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<td>Organizational learning may be effective if the lessons learned from completed projects are kept in the organizational memory and used in future projects, hence promoting stability in the owner’s behavior, and reduction of transaction costs.</td>
<td>POB2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A poorly defined scope and incomplete plans and specifications may increase the number of post-contract changes by owners, hence, increasing uncertainty in the owner’s behavior and increasing transaction costs.</td>
<td>POB3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good leaders have a project vision and know how to align people with their goals, inspire their team to take cooperative actions and to achieve project objectives, in turn, reducing transaction costs.</td>
<td>PME1</td>
<td>Project management efficiency</td>
<td>PME</td>
</tr>
<tr>
<td>Transaction costs are inevitably incurred in the decision-making process, but making sound decisions reduces the amount of time spent on unexpected problems, minimizes disagreements, and helps keeping a project on schedule and on budget, hence, reducing transaction costs.</td>
<td>PME2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective and efficient communication will ensure that all team members are aware of decisions as soon as they are made, leaving no room for uncertainty in terms of individual responsibilities and goals, hence, reducing transaction costs.</td>
<td>PME3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
UTE4 statement was considered in reverse, because it was built as a negative, in order to test the prior reading and knowledge of the participants in relation to research.

For testing the model, it was used structural equation modeling (SEM) with partial least squares (PLS). Hair Jr. et al. (2009) state that SEM is a multivariate statistical technique used to analyze direct and indirect relationships between independent and dependent variables. SEM is divided into 2 models, the measurement model that is concerned with the measurement of latent variables, working issues such as reliability and validity of the constructs, and the structure model that is concerned with the relationships between the constructs, demonstrating the amount of variance that is explained by the model (Hair Jr. et al., 2009).

Thus, there is the measurement model defined by the following equations presented in Box 2.

**Box 2 - measurement equations**

*Source: authors*

<table>
<thead>
<tr>
<th>UTE1 = f(UTE) + e1</th>
<th>CPB1 = f(CPB) + e6</th>
<th>POB1 = f(POB) + e9</th>
<th>PME1 = f(PME) + e12</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTE2 = f(UTE) + e2</td>
<td>CPB2 = f(CPB) + e7</td>
<td>POB2 = f(POB) + e10</td>
<td>PME2 = f(PME) + e13</td>
</tr>
<tr>
<td>UTE3 = f(UTE) + e3</td>
<td>CPB3 = f(CPB) + e8</td>
<td>POB3 = f(POB) + e11</td>
<td>PME3 = f(PME) + e14</td>
</tr>
<tr>
<td>UTE4 = f(UTE) + e4</td>
<td>CPB4 = f(CPB) + e9</td>
<td>POB4 = f(POB) + e12</td>
<td>PME4 = f(PME) + e13</td>
</tr>
<tr>
<td>UTE5 = f(UTE) + e5</td>
<td>CPB5 = f(CPB) + e10</td>
<td>POB5 = f(POB) + e13</td>
<td>PME5 = f(PME) + e14</td>
</tr>
</tbody>
</table>

To perform the data analysis in SEM, softwares SmartPLS 2.0 and SPSS version 23 were used. Critical path, in turn, points the hypotheses to be tested graphically, as shown in Figure 1.

**Figure 1 - critical path**

*Source: Li et al. (2013)*

Once defined model and techniques that were used for analysis, the next step follows with the results.
4. RESULTS

This chapter presents the results of the study. First, descriptive statistics of the sample and its relationship to the study are presented. Then, reliability of indicators are examined in the data collection instrument and in the addressed modeling. Finally, the outcomes are presented regarding structural model with existing factor weights.

4.1 Sample Profile

The researched universe can be composed by all the project professionals with decision-making competence in relation to transaction costs. The sample consists of 235 respondents, equivalent to 15% of questionnaires sent, totaling 1500.

By age group, sample is composed of 21% of professionals from 18 to 29 years-old, 66% of professionals from 30 to 49 years-old and 13% of professionals between 50 and 59 years-old.

Therefore, it was not presented respondents above 60 years-old, as shown in Chart 1.

In terms of academic background, 70% of respondents are Specialists, 27% of them are Masters and only 3% are Bachelors or similar, as shown in Chart 2.
In terms of professional experience, more than 50% of the sample is composed by professionals with experience between 3 and 10 years of work, 37% between 11 and 20 years, 9% have over 20 years of activity and the remaining 3%, less than 2 years of experience, as shown in Chart 3.

Regarding hierarchical position in the organizations, 62% of respondents are project managers, 19%
occupy position of area managers, 3% are directors and 16% are engineers, analysts or consultants, as shown in Chart 4.

![Chart 4 - hierarchical level](source: authors)

### 4.2 Reliability

One of the most important steps in the process of analyzing an SEM study is the reliability assessment of the data collection instrument. To test the reliability and validity of the data collection instrument, indicators used were composite reliability (CR), average variance extracted (AVE) and Cronbach’s alpha ($\alpha$). For a valid instrument, values shall be at least higher than 0.7 for $\alpha$, higher than 0.5 for AVE and higher than 0.70 for CR.

All variables were considered appropriate, according to proposed criteria, as shown in Table 1.

**Table 1 - reliability**

*Source: authors*

<table>
<thead>
<tr>
<th>V.O.</th>
<th>Cronbach’s alpha</th>
<th>average variance extracted</th>
<th>composite reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB</td>
<td>0.714</td>
<td>0.513</td>
<td>0.724</td>
</tr>
<tr>
<td>CPB</td>
<td>0.701</td>
<td>0.601</td>
<td>0.814</td>
</tr>
<tr>
<td>PME</td>
<td>0.703</td>
<td>0.501</td>
<td>0.701</td>
</tr>
<tr>
<td>UTE</td>
<td>0.718</td>
<td>0.502</td>
<td>0.820</td>
</tr>
<tr>
<td>TC</td>
<td>0.711</td>
<td>0.510</td>
<td>0.703</td>
</tr>
</tbody>
</table>
4.3 Test of structural model

With the instrument showing itself reliable, the next step is the analysis of the structural model. Accordingly, the structural model reported in Figure 2 shows the factorial forces existing within each of the latent variables.

![Figure 2 - structural model](image)

*Source: authors*

As can be seen in the model, the variable CPB presents a negative force in the transaction costs of 0.238. Similarly, it is possible to realize that there is no factorial pressure between POB and PME. However, the study was proposed to test the hypotheses previously presented and, according to the assessment of the correlation between latent variables, presented in Table 2, no hypothesis can be ruled out.
Thus, it is deduced that the model presented by Li et al. (2013) and applied in Brazil cannot has their hypotheses rejected by the chosen sample, according to the data analysis previously presented.

Box 2 synthesizes the results of hypothesis tests performed in this study.

<table>
<thead>
<tr>
<th>hypothesis</th>
<th>influence</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Predictability of project owner's behavior over transaction costs.</td>
<td>not rejected</td>
</tr>
<tr>
<td>H2</td>
<td>Predictability of contracted parties' behavior over transaction costs.</td>
<td>not rejected</td>
</tr>
<tr>
<td>H3</td>
<td>Uncertainty on transaction environment over transaction costs.</td>
<td>not rejected</td>
</tr>
<tr>
<td>H4</td>
<td>Project management efficiency over transaction costs.</td>
<td>not rejected</td>
</tr>
</tbody>
</table>

In view of not-rejection of any of the cases provided, some important aspects can be considered, which are addressed in the discussions.

5. DISCUSSION

The model was tested for this work in the Brazilian environment, and it had as main objective to verify the influence of (i) predictability of project owner's behavior, (ii) predictability of contracted parties' behavior, (iii) project management efficiency and (iv) uncertainty on the transaction environment, over transaction costs.

Since way, it was possible to observe a greater force on the reduction of transaction costs arising from predictability of the owner's behavior. This information gives light to other existing issues still as model answers, such as low existing load between project management efficiency in reducing transaction costs. The belief is that, for the responsible for project management, the importance of knowing the type of contractor exceeds the technical capacity, because of the history of unbalanced relationships between contractors and contracted parties. And this occurs mainly in the public spheres of contraction, with poorly defined scopes and questionable control criteria, which is corroborated by the existing force in the construct by affirmative POB3.
Afterward, uncertainty in the transaction environment presents significant weight to reduce transaction costs. Again, based in the affirmative UTE2, it can be stated that the contractor’s failure to define clearly the project is responsible for the increase in transaction costs. This issue is enhanced with a low volume of potential bidders, as shown in the affirmative UTE4. It adds to the level of uncertainty the potential complexity of the projects, which may result increase in transaction costs as well.

With the lowest load to reduce transaction costs, project management efficiency becomes impaired because of the Brazilian culture, which usually does not see the project manager ostensibly as an agent of change and financial and operational control for projects. This criticism can be supported by the existing low force in the affirmative PME1, presenting the project manager’s capabilities as tools to reduce transaction costs, different from affirmatives PME3 and PME2, respectively with higher forces, presenting exclusively the communication capacity of the manager as relevant in project management to reduce transaction costs.

To conclude the discussions on the model results, it is observed that the perception of the behavior of the contractor generates low negative influence on the reduction of transaction costs. One can believe that such phenomenon occurs by the permanent distrust of contractors in relation to contracted parties. This suspicion is supported by the existing force in the CPB3 and CPB1, representing the material replacements without prior approval and collusion suspicions, respectively, in project environment. In turn, the good relationship of previous projects (CPB2) is less intense in the reduction issues of transaction cost.

Thus, it is conceivable that, in Brazilian business environment, the concerns of managers in relation to transaction costs in projects are much more focused on contracting issues and business environment than in relation to the contracted parties and their ability to efficiently manage the project.

One possible way to better understand this issue is to perform a qualitative analysis of the real perception of project managers regarding business environment for projects development in Brazil.

The search for tools to reduce the level of uncertainty in relational projects environments would seek a lower cost of transaction, thus bringing to market more effective and competitive projects.

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The Cost of the Repairing Actions for Environmental Impacts Generated by The Implementation of Engineering Works

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ABSTRACT

Over the past 40 years, much has been written and spoken about Environmental Impact Studies and the Environmental Impact Assessment methods. In these studies, are suggested actions to sanitize (minimize, remedy and/or offset) the effect of the negative impacts generated by the implementation of an enterprise. The elaboration of a plan of repairing actions is a task so careful as the identification and assessment of impacts. Each action has a cost of implementation, maintenance and operation that shall be laid down in environmental studies. One must also take into account the unforeseen costs of a possible effect contrary to the expected result when the suggested action to mitigate a negative impact enhances its effect or generates another initially unplanned impact. Therefore, the objective of this paper is to present a proposal of a methodology for evaluating the economic feasibility of the implementation of the Plan of Repairing Actions for environmental impacts generated by the implementation of projects of any nature, through the use of a simple way to account for all the costs, taking into consideration the availability of the entrepreneur to pay to sanitize the negative impacts generated by his work.

Keywords: Cost-benefit analysis, environmental impact, repairing actions.

1. INTRODUCTION

The Brazilian Federal Constitution of 1988, in its Chapter VI (of the environment), article 225, establishes that “everyone is entitled to an ecologically balanced environment, common use of people and essential to healthy quality of life, and to the Government and the collective duty to defend it and preserve it for present and future generations”.

Previously to the Federal Constitution, on 31 August 1981, the Brazilian Federal law nº. 6 938 had defined the environment as being “the set of conditions, laws, influences and interactions of physical, chemical and biological order, which allows, shelters and governs life in all its forms. This law also defined the ad-
verse change of the characteristics of the environment as a degradation of environmental quality, what today we understand as environmental impact”.

However, the term environmental impact has only been legally defined in Brazil on 23 January 1986 by the National Environmental Council (CONAMA), through article 1 of the Resolution 001. The Resolution defined environmental impact as: “any change in the physical, chemical and biological characteristics of the environment, caused by any form of matter or energy resulting from human activities that directly or indirectly affect: I – health, safety and well-being of the population; II – the social and economic activities; III – the biota; IV – the esthetic and sanitary conditions of the environment; and V – the quality of environmental resources”.

Giansanti said (1998): “the term environmental impact won a more precise definition at the time that, in several countries, it was realized the need to establish guidelines and criteria for assessing adverse effects of human intervention in nature”. The author considers that “it is important to retain the definition of environmental impact, as it takes into account the effects on human activities, going beyond pure and simple defense of nature”.

In principle, any activity performed by the man causes an impact on the environment. They can be direct or indirect, beneficial or adverse, have different magnitudes, be temporary or permanent, be reversible or not, local or regional effects, but a human activity will always generate some kind of environmental impact.

Mining, agriculture and civil construction are the three human activities that generate more interventions on the environment where they are deployed. Of the three activities, civil construction is the most requested, since many of the projects require some sort of construction work. As an example can be cited the tourism industry, not engineering activity, but for its existence is required a robust infrastructure as good accommodation for tourists, fine dining, entertainment and leisure venues, such as beach structures, museums, theatres, etc., all associated with the good condition of the transportation system and access roads. Infrastructures that require high investment cost and that generate impacts (positive and negative) about the environment where they are deployed.

Apparently the engineering seems to be a great villain, but it is necessary to emphasize that their potential environmental impacts vary according to the type of work to be built and the area to be occupied by both the size and the location.

To determine the characterization of the impacts generated by an enterprise more specific studies are required, the most known of them is the Environmental Impact Study (EIS). The EIS is required by Brazilian legislation (CONAMA Resolution 001/86) for the execution of large engineering works and is an instrument of National Environmental Policy (Federal Law 6 938, August 31, 1981). The EIS of any project that falls within the parameters set by law, requires the diagnosis and analysis of impacts generated by activities on the physical, biological, economic and social environment (Ross, 2000).

When it comes to large enterprises or of activities potentially causing environmental impacts, is required, by the regulatory agencies, the implementation of a Plan of Environmental Monitoring and Control since
the installation phase of the construction site to the operation phase of the activities of the enterprise.

It is imperative that the EIS of a project is done by various professionals from different areas, working together. This multidisciplinary vision is rich, for the study be made complete and competent manner, in order to remove all doubts and problems (http://www.simonsen.br/semipresencial/pdf_meio/capi_2.pdf).

The Environmental Impact Assessment (EIA) is also one of the instruments of National Environmental Policy established by the Brazilian Federal Law 6 938, 31 August 1981. However, the process of institutionalization of EIA as a tool for environmental management was consolidated later with the approval of the Resolution. 001/86 from National Environmental Council (CONAMA) which laid down the definitions, the responsibilities, the basic criteria, as well as the general guidelines for the use and implementation of Environmental Impact Assessment, including the definition of repairing actions of negative impacts foreseen by the implementation of an enterprise.

Over the past 40 years, much has been written and spoken about Environmental Impact Studies and the Environmental Impact Assessment methods. However, studies so far refer to methods of impact assessment, but not much or almost nothing has been spoken and/or written about evaluation methods of mitigating, remedial and/or countervailing actions.

2. THE COST OF REPAIRING A NEGATIVE IMPACT

The negative environmental impacts, when these cannot be avoided, can be mitigated (by mitigating actions) or compensated (through compensatory actions). Some of them can be avoided through a preventive actions plan that should be followed carefully. Other impacts can be corrected through remedial actions.

The mitigating actions are designed to minimize or reduce the magnitude of foreseen negative impacts by the implementation of a project, whether directly or indirectly caused by the entrepreneur. When the impacts are not likely to mitigation, the entrepreneur must make use of compensatory actions and/or remedial actions (Diodato, 2004).

It’s desirable that the preventive actions be executed in a way that the process of generating environmental impacts is not triggered. According to Mota (2001), it is easier to avoid environmental degradation through preventive actions than fix the existing situations of environmental deterioration.

A repairing action becomes effective when it starts to be deployed at the beginning of the process of the study of alternatives of a project. When deployed at the end of the process, it tends to be more expensive and less efficient.

The Actions Plan is a component part of an Environmental Impact Study, in which is suggested the adoption of actions to minimize, remedy or offset the negative effects of the foreseen impacts by the implementation of an enterprise.

To draw up a plan of actions is a task as carefully as its own impact assessment. The actions must be
evaluated by the same process of EIA, but it may happen that some action has an opposite effect to the expected result, and instead of sanitizing the impact it could enhance it or cause an unplanned negative impact.

The cost to sanitize the negative impacts generated by an enterprise can sometimes be so high that it makes the work impossible, which leads the entrepreneur to drop the project or build it despising the actions proposed and approved in environmental study. In the two cases the entrepreneur loses money. In the first case, the capital invested cannot be recovered and in the second case, the work can be garnished by environmental agencies, causing more waste of financial resources.

Therefore, it is very important to make a careful analysis of the costs and benefits of the project, including the Plan of Actions Taken for the negative impacts.

3. COST-BENEFIT ANALYSIS

The Cost-Benefit Analysis (CBA) is a cost-effective technique applied to public decision-making which tries to quantify the advantages (benefits) and disadvantages (costs) associated with a particular policy or action.

According to the European project MESSINA (2006), the Cost-Benefit Analysis (CBA) is an evaluation method that gives an overview of the advantages and disadvantages of project alternatives or measures in terms of social welfare. These advantages and disadvantages are presented in the form of cost items and benefit items on a cost-benefit balance sheet. The items are expressed in terms of money (“monetised”) as far as possible to enable the various project alternatives to be compared. The main question in a Cost-Benefit Analysis is “Do the benefits outweigh the costs?”. The welfare effect is expressed in the balance of all costs and benefits (this is the net cash value). The differences in costs and benefits between the situation with the completed project and the situation that would arise if the project had not been carried out, indicate whether the project is socially desirable. The costs and benefits of alternatives can also be compared to determine which alternative is preferable.

A cost-benefit analysis is done to determine how well, or how poorly, a planned action will turn out. Although a cost-benefit analysis can be used for almost anything, it is most commonly done on financial questions. A cost-benefit analysis finds, quantifies and adds all the positive factors (the benefits), then identifies, quantifies and subtracts all the negative ones (the costs). The difference between the two indicates whether the planned action is advisable. For a cost-benefit analysis be well done, it is necessary to include all the costs and all the benefits and properly quantify them (Reh, s/d).

For Bursztyn (1994), the cost-benefit analysis is to assess gains and losses based on the “willingness to pay” of the entrepreneur. The “willingness to pay” expression is often understood as the maximum value that a user is willing to pay to have some benefit.

4. ECONOMIC FEASIBILITY OF A PLAN OF REPAIRING ACTIONS

As stated earlier, the cost of the repairing actions for the negative impacts can derail a project. Therefore,
the purpose of this paper is to analyze the costs of the implementation of the actions by a dichotomized form, that is, to analyze the direct and indirect costs in order to ensure that the actions are deployed (implementation cost), the direct and indirect costs to maintain them (maintenance costs) and the direct and indirect costs to ensure that they are operating (operation cost), as shown in Worksheet 1. This is a way to discriminate the costs and detect where adjustments can be made to the budget.

Worksheet 1 – Cost worksheet template of the repairing actions

<table>
<thead>
<tr>
<th>DESCRIPTION OF THE PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreseen Impacts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RUNNING TOTAL</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>GRAND TOTAL</th>
</tr>
</thead>
</table>

It is very important that entrepreneur declare his willingness to pay to make his project viable, i.e., it is important that entrepreneurs tell to the analyst his financial availability to facilitate the deployment and operation of his enterprise, including the Plan of Repairing Actions.

This financial availability must be determined before the start of the study, because that it what will guide the way of the work. It doesn’t mean that it cannot be altered during the development of the project.

When the maximum amount available for investment is known, one draws up a table where this value is divided into equal intervals, as shown in the Table 1. Thus, a growing range of sorting is created, where the cost of the Plan of Actions can be assessed as feasible, probably feasible, probably unfeasible and unfeasible.
In the same way the value of the costs is known, the value of the benefits generated by a correct deployment of proposed actions must be known, and within the concepts of cost-benefit analysis, the Plan of Actions will only be considered viable if the C/B rate is less than 1 (one), i.e., the costs (C) are smaller than the benefits (B).

### 5. PRACTICAL USE OF THE METODOLOGY

As an example of the use of the methodology proposed here, is considered the worksheet below:

<table>
<thead>
<tr>
<th>Foreseen Impacts</th>
<th>Repairing Actions</th>
<th>Implementation cost (R$)</th>
<th>Maintenance cost (R$/year)</th>
<th>Operation cost (R$/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production of waste from deployment and demobilization of building site</td>
<td>Acquisition of thermo-acoustic panels container</td>
<td>25 000</td>
<td>-</td>
<td>5 000</td>
</tr>
<tr>
<td>Loss of natural vegetation during the deforestation of land</td>
<td>Replanting of native plant species</td>
<td>10 000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Prejudice to the local and/or migratory wildlife habitat during the deforestation of land</td>
<td>Study of the flow of migration routes, seeking to carry out the minimum intervention in their habitats</td>
<td>5 000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Modification of insolation levels, temperature and lighting caused by the withdrawal of natural vegetation</td>
<td>Planting and maintenance of vegetation in the empty spaces and along the paths</td>
<td>15 000</td>
<td>5 000</td>
<td>20 000</td>
</tr>
</tbody>
</table>

| RUNNING TOTAL | 55 000 | 5 000 | 25 000 |
| GRAND TOTAL | 85 000 |
It was initially set by the entrepreneur a maximum limit of R$ 50 000 for execution of a Plan of Repairing Actions for the possible negative impacts.

So, the analyst develops the table with the scale of assessment of the cost for implementing the Plan of Action, as shown in the Table 2.

<table>
<thead>
<tr>
<th>VALUES (1 000 R$)</th>
<th>EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25</td>
<td>FEASIBLE</td>
</tr>
<tr>
<td>25 – 50</td>
<td>PROBABLY FEASIBLE</td>
</tr>
<tr>
<td>50 – 55</td>
<td>PROBABLY INFEASIBLE</td>
</tr>
<tr>
<td>&gt; 55</td>
<td>INFEASIBLE</td>
</tr>
</tbody>
</table>

According to the Table 2, the cost of the Plan of Action (R$ 85 000) of the sample show on in Worksheet 2 would be assessed as INFEASIBLE, indicating to the analyst the need to make adjustments in the initial proposal.

**6. FINAL CONSIDERATIONS**

This paper had as main objective the proposal of a methodology based on the cost-benefit analysis to assess the cost of implementation of a Plan of Actions to sanitize the negative effects of the environmental impacts generated by a project of engineering.

The use of a range of feasibility assessment, taking into consideration the availability of the entrepreneur to pay to get his project approved by the environmental agency, shows to the analyst (clearly) if the proposed Plan of Actions is within the budgetary limits of his client, allowing him to make adjustments, in the case of surpass these limits.

Although it was designed to be applied in the evaluation of costs of repairing actions of environmental impacts, the methodology proposed here can be adapted to be adopted in similar studies.

It’s always good to remember that a remedial action when well applied can change completely the nature of an adverse impact. Therefore, it is important to understand that although high, the cost of correct mitigation, compensation and/or remediation of negative effect of an impact then becomes the benefit of having a project approved without restrictions.
7. BIBLIOGRAPHICAL REFERENCES


Self-compacting concrete: cost analysis x productivity construction site compared to conventional concrete

Juliana Bevilacqua Jacob

ABSTRACT

Technological advances open new horizons of applicability of materials in construction. The development of new technologies and materials diversify the use of construction techniques in the construction site aimed quality and industrialization of construction generating productivity benefits and profitability in the work.

Based upon this paradigm, there is the intention of studying comparative methods costs between conventional materials and new applicability in construction site. As an example, it will be studied the cost-effective use of self-compacting concrete in relation to conventional pumped concrete. It will be used as a price reference source, tables with legal and current market value as well as their compositions official costs with productivity data. From data collected in reference tables, is exposed during the research the various situations for the application of self-compacting concrete in relation to cost-productivity citing actual examples of application. It is also carried out planning work with this new technology in relation to the assessment of local working conditions for decision management technical team.

After exposure cost parameters and productivity of self-compacting concrete is expected to work to deepen future studies covering the cost of self-compacting concrete in construction performing their technological and financial functions.

Thus, the choice of a material or application of technology to a structural element is first necessary a good feasibility study, including the physical and financial planning of the work. In this analysis should be considered the size of the building, the work runtime, neighborhood impact and the region to be built, hand-existing work, technology available on site, climate characteristics of the region to evaluate, from numbers and / or percentage the cost-benefit of building systems to be used.

Keywords: Self compacting concrete, planning, cost of building.
INTRODUCTION

The concrete term self-compacting - CAA is applied to a concrete category that has the ability to be molded into forms filling every empty space through its own weight without the use of assistive technology for densification or external vibration at the time of launch. It is a new technology, developed in the 1980s to the concrete in its fresh fill small spaces in forms with thick armor and after deform in their finished state, presents a free smooth surface of the famous “honeycombed” or gaps in concrete for lack densification.

Consequence of research applied to the use of superplasticisers additives and viscosity modifiers and also combined with high fines content (cement, mineral additions, fibre-, filler- etc.) to formulate concrete fluids and resistant to segregation is a technological evolution in the field of construction materials.

The technological breakthrough and methods of rule and dosage techniques and preparation, and also a significant reduction in cost of inputs, additives used as superplasticisers grade and viscosity moderators make the self-compacting concrete has thrust together technical professionals construction in the execution of structures.

The use of this new technology will reduce costs in the budget of the work, reduce the number of workers involved in launching the implementation of concrete on the construction site where in the near future will be one of the aspects to industrialization at the construction site. With the application of self-compacting concrete towards its facilities to launch and consolidation activities, improves the quality of the molded-site structures, reducing waste and improving the applicability conditions at the construction site when compared to running the same conventional concrete structures.

In Brazil, the self-compacting concrete still reacts limited basis. The lack of qualified professionals to accept new technologies in the use of concrete, the domain of some concrete supply leading companies in market and also the lack of information and dissemination are factors that influence many contractors and incorporators to continue with traditional methods pumped conventional concrete.

2. OBJECTIVES

This study aims is to study the costs of compositions from official reference tables (TCPO, SINAP) to check the cost of self-compacting concrete with respect to pumped conventional concrete and the application feasibility in the construction site, citing examples executed.

3. LITERATURE REVIEW

3.1.1 Definition, characteristics and history of self-compacting concrete

Self-compacting concrete - SCC is a type of concrete which from its cementitious material composition can be molded into form and fill voids in thick frameworks through its own weight, excluding the need for compaction or vibration by external means mechanical or manual source.
Characterizes its identity fluidity, stability and non-segregation of the material. Self adensabilidade is described as the ability of any material to fill spaces and involve steel bars and other obstacles through exclusively of gravity of the action, maintaining an adequate homogeneity. (TUTIKIAN, 2004, p. 27)

For a concrete be defined as self-compacting is necessary to ensure and provide three-Features: fluidity, cohesion or passing ability and resistance to segregation. Fluidity is the property of self-compacting concrete characterized by the ability to flow within the form and fill the spaces. Passing ability is a property in which the self-compacting concrete has the capability to drain the form moving through dense reinforcements without obstruction or flow separation. Segregation resistance is the property that characterizes the self-compacting concrete's ability to remain cohesive to flow within the forms, through or not through obstacles. (TUTIKIAN, 2004, p. 28)

The emergence of the self-compacting happened in Japan around the year 1983 by Professor Professor Okamura. Based on studies it was developed concrete to solve the problem of shortage of skilled labor and lack of sophisticated equipment to carry out the mechanical compaction of concrete in complex shapes and/or high density armor, usually to withstand existing local earthquakes, durability problems began to emerge in concrete structures. (CAVALCANTI, 2006, p. 25).

The development of self-compacting concrete had a strong impact on professional engineers and experts in concrete technology at the time. His first prototype occurred in 1988 in Japan and from the 1990s has spread rapidly in Japan and also in Europe. (TUTIKIAN, 2004, p. 32). Its main application was in Japan in 1997 with concreting of the bridge concrete anchors Akashi-Kaikyo, inaugurated in 1998, with 1,991 meters in clear span, and 290.00 m³ of self-compacting concrete in the forms of anchoring. The justification of the use of self-compacting concrete in this work was the execution speed, densification of the exemption (which would be difficult for the volume of concrete used) and the final quality of concrete.

**Figure 1** Bridge Akashi-Kaikyo, Japão
In Brazil, SCC still operates slowly. The lack of information and material composition by engineers and technical construction technology inhibits its use in construction site. That still makes self compacting concrete has a higher cost than conventional concrete.

### 3.1.1 Dosage and materials used in self-compacting concrete

The materials used for the preparation of self-compacting concrete are paticamente the same used in the conventional concrete - cement, fine aggregate, coarse aggregate and water added, but increased with the addition of fine materials (pozzolanic or not) - mineral or fillers additives and additives superplasticizers and viscosity modifiers. The superplasticizers additives allow the concrete reach high fluidity in your mix. The viscosity modifiers additives provide increased stability of the concrete, preventing the segregation and the exudation.

![Figure 2 SCC 50 MPA dosage fck (MARQUES, A. C.; BITTENCOURT, T. N.; BARBOSA, M. P.)](image)

<table>
<thead>
<tr>
<th>Components</th>
<th>SCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (kg/m³)</td>
<td>370,0</td>
</tr>
<tr>
<td>Quartz sand (kg/m³)</td>
<td>512,0</td>
</tr>
<tr>
<td>Manufactured sand (kg/m³)</td>
<td>420,0</td>
</tr>
<tr>
<td>Crushed stone 1 (kg/m³)</td>
<td>520,8</td>
</tr>
<tr>
<td>Crushed stone 0 (kg/m³)</td>
<td>347,2</td>
</tr>
<tr>
<td>Water (l)</td>
<td>180,0</td>
</tr>
<tr>
<td>Superplasticiser visocrete 3535 (kg/m³)</td>
<td>2,6</td>
</tr>
<tr>
<td>Superplasticiser Mira 94 (kg/m³)</td>
<td>2,4</td>
</tr>
<tr>
<td>a/c (kg/kg)</td>
<td>0,5</td>
</tr>
<tr>
<td>fck (MPA)</td>
<td>50,0</td>
</tr>
</tbody>
</table>

### 3.1.2 Applications and advantages of self-compacting concrete

The consolidation ability of self-compacting concrete eliminates the possibility of concretagem niches and holes, resulting in higher quality and durability of the structure. Another advantage is the possibility of large concrete reinforcement density regions forms, where there are difficulties in using vibrator, excluding the risk of exposure of the steel and deterioration of the structure.

Below is list of indications for use of self-compacting concrete:

- Foundation for pile continuous helix
- Wall, beams and columns
- Pillars of great heights
- Diaphragm wall
• Water treatment plants and sewage
• Water and pool Reservoirs
• Concrete floors, concrete subfloors, slabs, columns, walls and panels
• Places with difficult access for concrete pouring
• Small pieces of concrete, with many details or unconventional format where it is difficult to use vibrators
• Forms with large concentration of stirrups
• Structural reinforcement

3.2 Self-compacting concrete and Construction Planning

To use the self-compacting concrete in construction site must first be a good study of the construction planning. Aspects dosage, application sites, of the project execution time and costs should mainly be taken into consideration. Factors such as of the project location, impact of it in the neighborhood, runtime typology of the structural elements to be used, degree of difficulty of concrete pouring, risk analysis during the execution of the project and particularly the availability of knowledge of the technical team project influence the decision to choose between conventional concrete and high-performance concrete in its cost x benefit relation.

The exclusion of vibrator use, the reduction of noise in the environment and increased productivity in the field, led the SCC gain space quickly in the precast industry. Gradually the self-compacting concrete has been gaining space in the Brazilian civil construction scenario. After planning studies, there is the possibility of cost-cutting, better quality performance of pieces of concrete structure, launch facility, reduced hand labor in construction, significant reduction or almost nil rework caused by fallhas in concrete pouring.

A planning solution adopted for the choice of self-compacting concrete took place in the execution of the Work Station Light Line 4 - Yellow of Metro São Paulo SP, the Yellow Line Consortium. The SCC was used in the bottom slab concrete placement of the North and South pits, where 8 000 cubic meters of concrete were needed to fill a piece of 2 thousand square meters of surface area and about 3.5 m high, which concrete pouring process was executed in two steps to facilitate its implementation. According FARIA, 2008, self-compacting concrete was used to ensure the quality of the slab execution due to its dense armor due to its ease of release, not need vibration during concrete pouring and eliminate concrete pouring failures.
4. MATERIALS AND METHODS

4.1 Cost analysis and productivity of self-compacting concrete in relation to conventional concrete dosed at central.

The concrete structure for a building means a percentage from 21 to 23% of the cost of construction. In item structure, the concrete holds about 24.76% of its total value (BADRA, 2012 pg. 130). Analyzing the ABC curve of inputs according to MATTOS table 2015 for a work of a residential apartment block for the Minha Casa Minha Vida 2 Track 0, ready-mix concrete pumped fck 20 MPA is in its cost value of 3.15% of the total value of the project. (Fifth item of greatest impact on the cost of construction). Analyzing author data, JACOB 2011, concerning the work of expansion of the Galleria Mall in Campinas SP, the ready-mix concrete pumped fck 25 MPA and MPA 30 together represent a value of 3.01% of the value of the work. (Sixth item of greatest impact on the cost of construction). Through the curve ABC is the builder / entrepreneur or manager of the project is able to assess the impact that an increase or decrease in certain raw material prices will have on the results of the work. The more up the raw material is on the table, the more significant will be the impact on the work. (MATTOS, 2015 p. 178)
**Figure 4** Indexes in percentage of cost estimates for general buildings. (BADRA, 2012 pg. 130)

<table>
<thead>
<tr>
<th>Description</th>
<th>Complements</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings in general</td>
<td>ABC Curve</td>
<td></td>
</tr>
<tr>
<td>1 Structure</td>
<td>Concrete, frameworks and forms</td>
<td>21,00</td>
</tr>
<tr>
<td>2 Equipamentos electromecanica</td>
<td>Energy, light, frames, equipamentos, elevatores</td>
<td>14,50</td>
</tr>
<tr>
<td>4 Coating</td>
<td>Brickwork, ceilings and elevation</td>
<td>12,50</td>
</tr>
<tr>
<td>5 Equipamentos fluidynamics-sanitary</td>
<td>Brickwork, concrete panels, partition walls</td>
<td>7,00</td>
</tr>
<tr>
<td>6 Paviments</td>
<td>Floors, stairs and ramps</td>
<td>6,00</td>
</tr>
<tr>
<td>8 Fundations</td>
<td>Trench, girder beans, piles</td>
<td>4,00</td>
</tr>
<tr>
<td>9 Several</td>
<td>Gardens, cleaning</td>
<td>3,50</td>
</tr>
<tr>
<td>10 Indirect costs</td>
<td>Construction site facilities, IPE, vertical transport</td>
<td>3,30</td>
</tr>
<tr>
<td>11 Roof top</td>
<td>Roof tiles, waterproofing</td>
<td>1,00</td>
</tr>
<tr>
<td>12 Earthfill</td>
<td>Retaining walls, drainage, earth movement</td>
<td>0,70</td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>1 Concrete</td>
<td></td>
<td>24,76</td>
</tr>
<tr>
<td>2 Forms and frameworks</td>
<td></td>
<td>75,24</td>
</tr>
</tbody>
</table>

**Figure 5** ABC curve inputs: Work residential apartment block for Programa Minha Casa Minha Vida 2 faixa 0. (MAT-TOS, 2015)

<table>
<thead>
<tr>
<th>code</th>
<th>units</th>
<th>inputs</th>
<th>quantity</th>
<th>unit price (R$)</th>
<th>total cost (R$)</th>
<th>weight (%)</th>
<th>accumulated (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8111</td>
<td>h</td>
<td>janitor</td>
<td>6971,19</td>
<td>10,00</td>
<td>69,755,88</td>
<td>10,15</td>
<td>0,10</td>
</tr>
<tr>
<td>25070</td>
<td>uni</td>
<td>structural concrete block fck 4.5 mpa 14x19x39cm nbr 6136 wall</td>
<td>25057.94</td>
<td>2.45</td>
<td>61,506,52</td>
<td>8.95</td>
<td>0.19</td>
</tr>
<tr>
<td>597</td>
<td>m³</td>
<td>sliding window aluminium series 25, no banner with 4 sheet glass (two fixed and two mobile) 1.80x1,10m (including trim and flat glass colourless)</td>
<td>99,21</td>
<td>540,76</td>
<td>53,648,79</td>
<td>7.81</td>
<td>0.27</td>
</tr>
<tr>
<td>2783</td>
<td>m</td>
<td>piles concrete precast including setting and amendments - 20 t</td>
<td>695,21</td>
<td>89,69</td>
<td>48,470,78</td>
<td>7.05</td>
<td>0.34</td>
</tr>
<tr>
<td>4750</td>
<td>h</td>
<td>hod carrier</td>
<td>3771,09</td>
<td>11,04</td>
<td>41,037,83</td>
<td>6.66</td>
<td>0.41</td>
</tr>
<tr>
<td>1524</td>
<td>m³</td>
<td>pumped concrete fck= 20,0 mpa</td>
<td>80,44</td>
<td>269,31</td>
<td>21,663,49</td>
<td>3.15</td>
<td>0.44</td>
</tr>
<tr>
<td>6115</td>
<td>h</td>
<td>assistant</td>
<td>2065,32</td>
<td>10,00</td>
<td>20,668,18</td>
<td>3.00</td>
<td>0.47</td>
</tr>
</tbody>
</table>
### Figure 6
ABC curve inputs: Expansion work at the Galleria Shopping Campinas. (JACOB, 2011)

<table>
<thead>
<tr>
<th>ABC CURVE</th>
<th>COST CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Provider</td>
</tr>
<tr>
<td>8.3.1</td>
<td>Manufacture and assembly of prefabricated concrete</td>
</tr>
<tr>
<td>4.11.10</td>
<td>Labor Structure</td>
</tr>
<tr>
<td>14.2.2</td>
<td>Sash</td>
</tr>
<tr>
<td>9.2.2</td>
<td>Metal structure</td>
</tr>
<tr>
<td>4.1.9</td>
<td>Steel</td>
</tr>
<tr>
<td>8.4.5</td>
<td>Machined concrete</td>
</tr>
<tr>
<td>5.1.1</td>
<td>Bedding planes and waste area</td>
</tr>
<tr>
<td>20.1.1</td>
<td>Ecopietra Floor</td>
</tr>
</tbody>
</table>

### 4.2 Concrete costs composition
Self-compacting and conventional concrete pumped based on reference tables

Taking as a study indicating the reference price list as TCPO 14 (Prices Composition Tables for Budgets VERSION 14) PINI, the cost of conventional concrete fck 25 MPa in relation to self-compacting concrete is 29.91% more cheaper than the self-compacting concrete. In the same database there are no cost composition for application to concrete. This shows that there is still much shyness and restraint regarding the applicability of self compacting concrete.

### Table 1
Cost composition for conventional concrete fck 25 MPa for structure, pumped, TCPO PINI

<table>
<thead>
<tr>
<th>TCPO 14 - PINI</th>
<th>Conventional concrete fck 25 MPa for structure, pumped</th>
<th>1 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>Description</td>
<td>Un.</td>
</tr>
<tr>
<td>05.004.000099.SER</td>
<td>Concrete - Application and densification with electric motor immersion vibrator</td>
<td>m³</td>
</tr>
<tr>
<td>01.021.000001.MOD</td>
<td>Hod carrier</td>
<td>h MOD</td>
</tr>
<tr>
<td>01.026.000001.MOD</td>
<td>Janitor</td>
<td>h MOD</td>
</tr>
<tr>
<td>36.003.000041.EQH</td>
<td>Vibrator immersion, electric, power 1 HP 0.75 KW</td>
<td>h prod</td>
</tr>
<tr>
<td>04.002.000016.SER</td>
<td>Structural concrete dosed in central fck 25 MPa, dejection 8 ± 1 cm</td>
<td>m²</td>
</tr>
<tr>
<td>06.004.000009.MAT</td>
<td>Concrete machined fck 25 MPa gravel 1 and 2 abatement 8 ± 1</td>
<td>m³</td>
</tr>
<tr>
<td></td>
<td>Total Material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Workforce (excluding Social Laws)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total m³</td>
<td></td>
</tr>
</tbody>
</table>
Analyzing other source of reference prices, SINAPI base date 10/2015, the cost for concrete pumpable fck 20 MPA surprisingly was 4.94% below the cost of self-compacting concrete. In the total composition of cost to supply and application of the concrete, self-compacting concrete also takes advantage forward with 8.19% than conventional concrete. Regarding placing of concrete, the economy in adopting the use of self-compacting concrete is at 72.14% cheaper manpower compared to conventional concrete. The gain in labor, project productivity, the exclusion of vibrator use makes the applicability of self compacting concrete is more efficient and economical in construction site.

Table 3 Cost Composition Concrete fck 20 MPa for structure, SINAP 10-2015
### Table 4 Cost Composition Concrete Self-compacting concrete fck 20 MPa for structure, SINAP 10-2015

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Un.</th>
<th>Clas.</th>
<th>Coef.</th>
<th>United Price (R$)</th>
<th>Total (R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11147</td>
<td>Concrete self compacting concrete (scc) c20 strength class, spreading sf2 includes m³ pumping service (nbr 15823)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11147</td>
<td>Concrete self compacting concrete (scc) c20 strength class, spreading sf2 includes pumping m³ MAT</td>
<td>1.00</td>
<td></td>
<td></td>
<td>250.52</td>
<td>250.52</td>
</tr>
<tr>
<td></td>
<td>Total Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R$ 250.52</td>
</tr>
<tr>
<td></td>
<td>Total Workforce (excluding Social Laws)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R$ 250.52</td>
</tr>
<tr>
<td></td>
<td>Total m³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R$ 250.52</td>
</tr>
</tbody>
</table>

### Table 5 Cost Composition Concrete fck 20 MPa to structure release, SINAP 10-2015

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Un.</th>
<th>Clas.</th>
<th>Coef.</th>
<th>United Price (R$)</th>
<th>Total (R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>39953</td>
<td>Concrete machined pumpable, c20 strength class with crushed stone 0 and 1, slump = 190 +/- 20 mm, m³ includes pumping service (nbr 8953)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88262</td>
<td>Carpenter forms with additional burdens</td>
<td>H</td>
<td>MOD</td>
<td>0.163</td>
<td>18.68</td>
<td>3,04484</td>
</tr>
<tr>
<td>88309</td>
<td>Hod carrier with additional burdens</td>
<td>H</td>
<td>MOD</td>
<td>0.653</td>
<td>18.68</td>
<td>12,19804</td>
</tr>
<tr>
<td>88316</td>
<td>Janitor with additional burdens</td>
<td>H</td>
<td>MOD</td>
<td>0.734</td>
<td>16.03</td>
<td>11.76602</td>
</tr>
<tr>
<td>90586</td>
<td>Immersion Vibrator, tip diameter 45mm, three-phase electric motor power of 2 hp - Day chp. Af_06 / 2015</td>
<td>H</td>
<td>CHP</td>
<td>0.06</td>
<td>1.93</td>
<td>0.1158</td>
</tr>
<tr>
<td>90587</td>
<td>Immersion Vibrator, tip diameter 45mm, three-phase electric motor power of 2 hp - Day chl. Af_06 / 2015</td>
<td>H</td>
<td>CHI</td>
<td>0.103</td>
<td>1.32</td>
<td>0.13596</td>
</tr>
<tr>
<td>39953</td>
<td>Concrete machined pumpable, c20 strength class with crushed stone 0 and 1, slump = 190 +/- 20 mm, m³ includes pumping service (nbr 8953)</td>
<td></td>
<td></td>
<td></td>
<td>263.55</td>
<td>287,2695</td>
</tr>
<tr>
<td></td>
<td>Total Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R$ 287.52</td>
</tr>
<tr>
<td></td>
<td>Total Workforce</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R$ 27.01</td>
</tr>
<tr>
<td></td>
<td>Total m³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R$ 314.53</td>
</tr>
</tbody>
</table>
According FARIA, 2008, for comparing the costs x productivity of the use of conventional concrete with self-compacting concrete, there was a partnership between the Engemix companies and BKO construction for a case study in the residential Pateo São Paulo SP work. This study was the cost of concrete pouring with two concrete alternatives for cost optimization purposes and application of labor.

The first positive response obtained in relation to self-compacting concrete was the concreting time reduced by 50% to conventional concrete. For this we used two slabs to be concreted 250 m² each, which were performed with 50 m³ of each of the concrete to reach the fck 50 MPa at 28 days. The two concrete pouring had the same characteristics where the pumps and concrete mixer trucks had the same technical characteristics, using hose 4”. The slabs and beams the fourth floor were concreted with conventional concrete and total concreting time was at 4:40. The slab of the fifth floor was concreted with self-compacting concrete where possible to implement the slab with half the time spent on conventional concrete. Self-compacting concrete characteristics such as fluidity and eliminating the time spent on the vibration of the concrete allowed reduction of hand labor time and therefore the costs of the constrution. In this sample, the cost of labor for the application of concrete including charges were respectively R $ 7.18 / m³ for conventional concrete and R $ 0.70 / m³ for the self-compacting concrete.
Analyzing the sample of concrete pouring, there was a significant gain in production application of self-compacting concrete. The amount of staff stopped during the concrete pouring process of self-compacting concrete vary between the concrete car 50% to 56.25% of the amount of men involved. In conventional concrete, the amount of men standing ranges from 6.25% to 18.75% of men standing. The amount of spreaders and launchers the self-compacting concrete varied 18.75% to 31.25% between the first and last concrete car at work. The amount of spreaders and launchers of conventional concrete ranges from 37.5% to 50.0% involved. It was reduced to 100% the number of vibrators in self-compacting concrete due to its characteristic of being thickened by himself. It can be concluded that there was a productivity gain of up to 70% of self-compacting concrete compared to conventional concrete.

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Conventional</th>
<th>Self-Compacting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete-mixer truck</td>
<td>1° 2° 3° 4° 5° 6° 7°</td>
<td>1° 2° 3° 4° 5° 6° 7°</td>
</tr>
<tr>
<td>Number of concrete launchers</td>
<td>3 3 3 3 2 2 2</td>
<td>2 1 2 1 1 1 1</td>
</tr>
<tr>
<td>Number of concrete spreaders</td>
<td>5 4 5 5 5 4</td>
<td>3 3 2 2 2 2 2</td>
</tr>
<tr>
<td>Number of vibrators</td>
<td>2 2 2 2 2 2 2</td>
<td>0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Number of finishers</td>
<td>0 2 3 3 3 3 4</td>
<td>0 0 1 2 2 2 2</td>
</tr>
<tr>
<td>Number of striking employees</td>
<td>3 2 0 0 1 1</td>
<td>8 9 8 8 8 8 8</td>
</tr>
<tr>
<td>Other employees</td>
<td>3 3 3 3 3 3 3</td>
<td>3 3 3 3 3 3 3</td>
</tr>
<tr>
<td>Total employees</td>
<td>16 16 16 16 16 16 16</td>
<td>16 16 16 16 16 16 16</td>
</tr>
</tbody>
</table>
5. CONCLUSIONS

This article aims to contribute to development of future work in the area of technology and planning constructions. With the analyses are expected to work to deepen future studies involving cost of concrete self compacting concrete in construction, performing their technological and financial functions.

For the choice of a particular material or application of technology to a structural element is first necessary physical and financial planning of the work context. In this planning study should be considered size of the building, the work runtime, neighborhood impact area that will be built, existing manpower on site (if it is specialized or not) technology available on site, climate characteristics of the region to evaluate, from numbers and/or percentage the cost-benefit of building systems adopted.

It is worth noting that the self-compacting concrete has its money on various factors set out in Article. Its application technology goes to work industrialized with little application of hand labor, reducing pollution and preserving the environment. This new concrete technology can be said to come to gradually replace the conventional concrete pumped, because from good planning of construction covering aspects of production, dosage and cost, there is no reason to continue the use of conventional concrete.

6. REFERENCES

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How to Effectively Change the World
Celso Ramos, Edson Marinho, Juliana Cariello, Pietro Guedes, Luiz Rocha

ABSTRACT

Globally, there are thousands of development organizations working to relieve suffering, promote the interests of the poor, protect the environment, provide basic social services, or undertake community development. Together, these organizations form an extremely heterogeneous group but differ in an array of ways. Some are government affiliated, others bilateral or multilateral agencies; many are associated with educational institutions, and most are non-governmental organizations (NGOs).

Nevertheless, while development organizations are heterogeneous and unique in many ways, they all share one thing in common: their main reason to exist is to create social transformation managing their initiatives as projects. The success of all these organizations and the livelihoods and well-being of the hundreds of millions of people they serve depends on their ability to deliver project results effectively and efficiently. These organizations must develop teams to elaborate project proposals, to develop project plans, to implement project activities (many with the essential help of the beneficiary community), and to monitor their progress and evaluate their impact. Unfortunately, project management is rarely identified as a strategic priority for these organizations although a culture of project management should pervade their work.

In 2011 McKinsey-Devex published a survey on Development Agency Effectiveness. Only 36% of those surveyed said that most aid projects achieved their intended impact. The four main areas needing improvement were: planning for financial sustainability, ensuring stakeholder skills to sustain the programme, forward-planning allocations and evidence-based resource allocation.

This paper will share the approach of PMDPro (PM4NGOs), which helps development organizations and NGOs to organize their initiatives as projects. The main reason for this approach is to adapt the project management approach for the specificities of the development sector.

Using the PMD Pro methodology as a reference, the specificities of the development sector will be explored. The goal is to have a standard approach to deal with scarce resources, high risks, unsafe conditions, unstable political and economic environments, and stakeholder complexities which can guarantee successful results according to the established objectives and deliver the intended benefits to the targeted populations.

Keywords: PMD Pro Guide; Development Sector; Project Management; PM4NGOs; IPMA
DEVELOPMENT SECTOR PROJECTS CHARACTERISTICS

Development projects usually have less tangible goals. Besides, the results might be less visible and measurable when compared to infrastructure and industrial projects. These are some of their particularities:

- The intangibility of project objectives and deliverables requires adaptation of the existing project management bodies of knowledge and adoption of new tools and concepts to define, monitor and measure to what extent the development projects achieve these objectives. Neglecting this important aspect usually leads to the tendency of measuring only resource mobilization and efforts, rather than results. The consequence is the inefficient use of development funds and long-term lack of accountability (Khang & Moe);

- Most projects also have an ultimate goal to produce positive and significant changes that will be sustained after the external assistance comes to an end. This sustainability requirement adds a new level to the intangibility of the development outcomes. It becomes mandatory to track closely the benefits to be delivered since project deliverables are only a means to an end of improving the welfare of the population benefiting from the project.

Most international development projects have a complex web of stakeholders involving three separate key stakeholders: the funding agency that does not directly use the project outputs; the implementing unit, responsible for the best utilization of the resources available; and the target beneficiaries who actually benefit from the project outputs but normally do not pay for the projects. These key actors imply some characteristics of these projects: first, since most of the projects are implemented in developing countries where corruption often takes place, financial accountability and transparency is as important as the processes in place to complete projects within time and cost; second, the huge cultural gap between donors and target groups may result in poor project design and consequently failure in implementation.

On the other hand, development projects have some similarities to projects in other areas:

- Results must be achieved within time, budget, quality, scope;

- Project plans must be comprehensive, detailed, and manageable over the entire project life;

- Potential risks must be identified and monitored to guarantee the expected results and benefits.

Other particularities of development projects are:

Lack of shared perception and agreement on the objectives of the project by donors, government, and other stakeholders;

- Lack of commitment to the project by the team, management, and stakeholders;

- Lack of detailed, realistic, and current project plans (schedule, budget, and procurement);

- Unclear lines of authority and responsibility (organization not structured for project management);

- Lack of adequate resources, especially from government;
- Poor feedback and control mechanisms for early detection of problems;
- Poor or no analysis of major risk factors;
- Delays caused by bureaucratic administrative systems (approvals, procurement, personnel, land acquisition, and release of funds).

To navigate through this complex scenario, development projects require several competencies that can be classified as:

- Technical – these are often referred to collectively as the ‘science’ behind project management. The project manager must identify, select and employ the right tools and processes to ensure project management success and adapt them to project needs as necessary;
- Leadership/Interpersonal – often referred to collectively as the ‘art’ of project management. The project manager must communicate, inspire, align teams and resolve conflicts along the project life-cycle;
- Personal/Self-Management – to understand others you must first understand yourself. The project manager must have empathy with others, and effectively prioritize, manage time and organize work;
- Development Sector Specific – the project manager must understand the context of his specific project and the existing multi-layers through which decision making and monitoring will take place.

As project managers’ responsibilities increase from relatively simple projects to more complex projects, the knowledge, skills, behaviors, and experience will need to increase commensurately. It is undisputable that project managers must take responsibility for their career path and permanently build their personal, interpersonal and development sector-specific competencies.

**THE VALUE OF ESTABLISHING A METHODOLOGY FOR DEVELOPMENT PROJECTS**

Some organizations have the capability of consistently delivering projects effectively while others do not. Using standard lifecycle processes and techniques will help coordinate resources to achieve predictable results. Although the existence of a project life cycle is no guarantee of success, it does help to deal with the complexities and uncertainties involved, increases the odds of success and provides governance and alignment to the project and the stakeholders involved.

A methodology is a set of methods, processes, and practices that are repeatedly carried out to deliver projects. The key element is that by repeating the same actions on every project the organization will gain efficiencies in its approach. A project methodology should contain a standardized lifecycle processes to manage the phases of the lifecycle, tools and templates.

International development projects present peculiar characteristics (Golini, Landoni) that require specific methodologies:

- The target “customer” or beneficiary is a community in a developing country with boundaries and requirements that can be difficult to access. As a consequence, beneficiaries are often not included in the project design phases leading to fatal errors in the execution of the project;
• The presence of a large number of key stakeholders may result in the lack of involvement and communication leading to inappropriately defined project objectives;
• An array of social factors must be taken into account, including, among others, workforce availability, social instability, and the presence of different communities with conflicting interests;
• The diversity in culture and values can create considerable challenges, the most frequent of which revolve around assumptions, expectations, and language;
• Development projects normally have objectives such as poverty alleviation, living standards improvement, and basic human rights protection. These humanitarian and social objectives are usually intangible, not visible, and difficult to measure.

Reaping the benefits for utilizing a standard project methodology in the international development sector takes time and effort. Many may complain that the adoption of standard procedures introduces overhead, cost and waste of time. However, the problems presented above indicate that standardization, discipline, and governability are mandatory. First of all, grouping activities into a project life cycle sequence enables the project team to:

• Define the phases that connect the beginning of a project to its end and articulates its governability;
• Enable the creation of decision points to evaluate the continuity or not of the project and if a new course should be pursued;
• Identify the processes that project teams must implement as they move through the phases of project life cycle;
• Implement a project life cycle model improved by lessons learned and to be used in future projects.

THE PMDPRO METHODOLOGY FOR THE INTERNATIONAL DEVELOPMENT SECTOR

In 2007 LINGOs, an NGO focused on delivering learning solutions to development organizations that are appropriate, affordable, accessible, and actionable, began to work with a group of international NGOs to collectively establish principles and best practices in project management in the development sector. The work of that group laid out a methodology which was developed and field tested by over 200 practitioners from 15 organizations in 20 countries. While good project management principles are universal, PMD Pro builds on established methodologies to provide practical guidance to running development projects. PMD Pro Guide was launched in 2010 in Johannesburg and Zambia. Since then over 10,000 individuals in over 70 countries have been trained on the approach and have been using it.

The purpose of PMD Pro’s Project Phase Model is to provide a balanced and comprehensive phased model. Balance and comprehensiveness in the project model are especially important within the context of the development sector. Too often, development organizations have placed an especially strong emphasis on project design, monitoring, and evaluation and overshadowed the importance of other phases. A project must not only invest in one strong, coherent phase, but also commit similar levels of resources and effort in all the phases in the life of the project. The PMD Pro phased model is shown below:
The six phases presented on the illustration include:

**Project Identification and Design** – All projects begin as an idea. This idea is related to a need, a problem or an opportunity that is assessed, analyzed, and which is managed through the project life cycle. It is during this process that we begin answering the critical questions: 'What is the problem?'; 'What is the desired transformation?'. Get it wrong here, and the project may pursue a track of failure. It is during this phase that the project teams define needs, explore opportunities, and analyze the project environment. The decisions made during the Project Identification and Design Phase set the strategic and operational framework within which the project will subsequently operate.

A tool used during this phase is the logical framework (Logframe). The Logical Framework Approach was developed in the late 1960’s to assist the US Agency for International Development in improving its project planning and evaluation system. The Logframe has become a standard approach required by many donors for grant applications. Although it is very well known in the humanitarian sector, it is neglected in the corporate world. However, the Logframe is of paramount importance, providing:

- A systematic and visual tool for organizing the project thinking and identifying relationships between resources, activities, and project results that enable clarifying the underlying cause-effect interdependencies, defining indicators to measure progress, and identifying external factors and assumptions which will ultimately determine project success;
- A framework that makes the underlying rationales and assumptions transparent, facilitating the identification and assessment of risks inherent to all projects;
- A results-based management approach that brings logic, clarity and accountability into the planning, monitoring, and evaluation of the project.

While there are many versions of project logical frameworks, the PMD Pro subscribes to a four-level logical framework model that includes the following deliverables:
1. Activities are actions taken, through which inputs (financial, human, technical, material and time resources) are mobilized to produce the deliverables (training, constructing, etc.) of a project for which staff can be held accountable and which, when aggregated, produce outputs.

2. Outputs are tangible deliverables resulting from project activities. They include products, goods, services and changes (e.g. people trained with increased knowledge and skill; quality roads built) that aggregate and contribute to outcomes.

3. Outcomes are what the project expects to accomplish at the beneficiary level (e.g. use of knowledge and skills in actual practice over time; transportation of goods on constructed roads over time) and contribute to population-level changes (reduced malnutrition, improved incomes, improved yields, etc.) that aggregate and help bring about the accomplishment of goals and impact over time.

4. Goals are the highest-level desired end results or impacts (transformation, sustainability, livelihood, well-being, etc.) to which the project contributes (the ultimate objective in many logical frameworks).

The deliverables are integrated into a logical way that enables the many stakeholders to understand the project as a whole or through their particular perspective as shown below:

**Illustration 2:** PMD Pro’s Logical Framework
As such, the logframe must be used to improve project design, foster project performance, and facilitate project management. It provides a simple summary of the key elements of the development initiative in a consistent and coherent way that enables the identification of broad boundaries and further project detail during the next phase;

**Project Set Up** – Every successful project has a thoroughly planned and implemented Set Up phase with the following objectives:

1. Establishing the Project Governance Structure – In the context of project management, governance defines the management framework within which project decisions are made. It is the process of decision-making and the process by which decisions are implemented or not. A robust governance structure clarifies the following: authority, i.e. who has the power to make decisions and within what tolerance levels, and accountability, i.e. who is accountable for the success of the project. With no clearly accountable individuals, hidden agendas emerge turning the project into an instrument for the interested few.

   There is not a one-size-fits-all approach to governance. Governance needs to fit the organizational structure, culture, and complexity to be effective (PMI, 2016). Good governance has 8 major characteristics (UN-ESCAP): participation with freedom of expression on the one hand and organization on the other; rule of law of the procedural frameworks implemented; transparency of the decisions taken according to the rules of laws; accountability and clear definition of roles and responsibilities; responsiveness to serve stakeholders in a timely manner; consensus-oriented in order to mediate the different interests involved; equity and inclusiveness ensuring that all have a stake in the project and do not feel excluded; effectiveness and efficiency to meet the needs of stakeholders while making the best use of resources available.

   Governance structure can be set in different formats: The Sponsor (simple projects) or the Project Committee (more complex projects). The larger the number of Committee members, the more difficult it is to come to decisions. If the Committee is the adopted format, at least one member must have a senior executive perspective (role). Also, it is important to guarantee the presence of a senior user perspective (beneficiaries) and one member as a senior supplier (implementing partner). Each member represents a different perspective of what the success of the project means.

2. Officially authorizing the start of the project – It is crucial that a project has been formally authorized to start by the governance (sponsor or committee) through a Project Charter, which must be signed by all main stakeholders and partners as well as by the project manager.

   Once the Project Charter is signed, it will authorize the use of resources, guarantee a shared understanding of the project, and document the shared commitments to achieve the project outcomes and goals.

   Do not underestimate the value of the project charter. It is such an important document that a project should not be started without one. Not having a project charter hinders the project manager from being successful in his role and consequently impacts project success.

3. Communicating the project launch – the purpose of this phase is threefold: to formally acknowledge
the beginning of project; to ensure that key stakeholders have a consistent understanding of the project; to introduce stakeholders to the project.

The project kick-off meeting is an opportunity to foster a foundation of communication and understanding, share the information on the project charter, energize the team, set proper expectations, and establish guidelines on how to develop the project plan. If you fail to prepare for this meeting, you'll put the project at risk right from the start and miss the opportunity to have everyone on the team on the same page.

**Project Planning** – Once the project is authorized, the planning phase involves analyzing the work to be done, the dependencies and risks involved, the timing and resources to be allocated. Choosing to rush through or ignore the project planning process can be a formula for failure. This is also the time to explore and make adjustments since the cost of change is much lower than in later stages, as shown in the figure below.

![Illustration 3: Cost of Change](image)

In reality, the planning phase must address the 5W2H (explained in the figure below). This tool has been used widely by journalists to establish good narratives. In project management it is important to maintain objectivity, simplicity and guidance to action answering the why, where, who, what, when, how and how much of every project. The figure below illustrates the relationship between 5W2H and the main project disciplines.
Why do the Project?

Projects are undertaken for a variety of reasons, but, in the end, the investments are made because of the potential value the project will provide to the stakeholders involved. For example:

- The donor organization needs to be convinced that an investment in this activity would be a worthwhile investment;
- The community where the project will work needs to perceive that its participation will result in concrete benefits;
- The leadership of the development organization needs to be assured that the success of the project will contribute to its larger program (or portfolio) goals.

Strong project justification management helps demonstrate why a project makes solid sense to the organization, the donor, and the beneficiary communities. Successful project managers need to have the skills and competencies to:

- Identify the justification for their projects;
- Communicate the justification to a larger audience;
- Track the project progress in achieving the value that justified its existence.
Where to implement the Project?

Project context is the environment in which a project operates. It covers both the internal and external environment. Different projects have different contextual issues to deal with, therefore it is important to understand a project’s context. It is always possible to increase the chances of success for the project when opportunities and obstacles are identified.

The PESTLE technique can be used to analyze six main components of a project context: The Political, Economic, Sociological, Technological, Legal and Environmental.

Who are the stakeholders?

Development projects are complex and impact an array of stakeholders - individuals, groups and organizations who are actively involved in a project, or whose interests might be positively or negatively affected by execution or completion of the project.

Experience shows that when stakeholders are overlooked or misunderstood in the project design, or their interests are poorly considered, or worse, excluded during project planning and implementation, it can often result in unexpected and undesirable outcomes. In contrast, those projects that take time to identify and understand stakeholders benefit from:

- A clearer understanding of the individuals, groups, and institutions that will be affected by and should benefit from project activities;
- A better indication of the capacities of these stakeholders;
- A more informed understanding of who could influence and contribute to the planning and implementation of the project;
- An improved perspective on alternatives for designing project interventions and addressing project conflicts.

To succeed, the project team needs to develop the discipline to manage the stakeholders' relationships. Team members need to understand the reality and the complexity of interests and relationships; evaluate and predict project impacts (both positive and negative) on all stakeholder groups; and design and implement engagement plans that encourage project participation and strong communication.

One important principle in project management is participation. Include a variety of perspectives in the help to ensure transparency, clarify needs and expectations, improve quality, and strengthen buy-in at all levels.

What are the risks?

Effective risk management allows you to identify your project’s strengths, weaknesses, opportunities, and threats. By planning for unexpected events, you can be ready to respond if they arise. To ensure project’s success, define how you will handle potential risks so you can identify, mitigate or avoid prob-
lems when you need to do. During the earliest stages of project identification and design, the team will start to gain an initial understanding of the potential risks that could confront the project. Comprehensive risk management will focus both on negative risks and positive ones. The negative risk is represented by potential events that could harm the project. In general, these risks are to be avoided. Positive risk, on the other hand, are opportunities and are desired by both the project manager and the stakeholders and may positively affect the project.

What is going to be developed? How will the work be implemented?

Projects exist to deliver a service or product. To do so, there is a need to define what is going to be developed (features and functions that characterize the product or service) and how it is to be developed (the work that needs to be done to deliver the product or service) as well as the involved dependencies. Both of these components are critical to project success and need to be managed diligently. In the absence of a clear scope definition, the following problems may arise:

- **Unclear Expectations** – A clearly identified and developed project scope helps stakeholders to share a common understanding of the product and the work required to deliver project outcomes and outputs successfully.

- **Inaccurate Estimates** – To plan a project, a number of estimates must be made. If project scope is not adequately defined, these estimate failures can result in schedule slips and hence finally cost overruns that will impact project justification.

- **Scope Creep** – The purpose of defining scope is to describe clearly and gain agreement on the boundaries of the project deliverables and the project work. Failure to control these boundaries leads to a scope creep— a principle cause of project delays and potentially “never-ending” projects. To avoid creep, the scope needs to be documented and managed for the duration of the project through a formal change process.

During scope elaboration, the connection between the logframe and the scope demonstrates two important principles of project management: integration between different phases of project management; iteration as a mean of revisiting and detailing the different processes as a way of reducing uncertainties along the project.

When are the project activities going to be developed? How much will they cost?

Successful delivery of a project will always take place in the context of assumptions and constraints. Normally, project management is concerned with the triple constraints: scope, related to the products/services that the project will produce and the work required to produce these deliverables; cost/resources, related to the money, materials, and effort to deliver the project product/services and to complete the comprehensive work of the project; and time/schedule related to the amount of time required to complete the components of the project.

These three fundamental constraints show once more the need for integration in project management. Considering that resources are scarce and that they must be optimized, it is not possible to influence one
of these constraints without impacting the other two. One of the most important and most challenging jobs of a project manager is to organize effectively and efficiently all the resources involved in a project. The manager must know how to create and stick to a budget so that funds are allocated when and where they are needed, and effectively organize the team and guarantee that the right people are assigned, and appropriate tasks, clear roles and accountability in place. Also, it is necessary to have an effective deployment and flow of services, supplies and inventory so that the project has access to what it needs, when and where it needs it and at the most appropriate price.

Development sector organizations usually rely on individual or organizational donors to fund programs – and they expect donations to be well managed. Development organizations also have an obligation to the communities and partners they serve, being responsible for ensuring that resources obtained on their behalf are used in an optimal manner to maximize impact.

Project Implementation and the Discipline of Getting Things Done – Implementation is a specific set of behaviors and techniques to be mastered to achieve success. It is a discipline of its own. At the implementation level, objectives that involve organizational transformation, require a shift or improvement in people skills (Bossidy, Charan). At the same time, no plan is immutable. As the project progresses issues will arise and changes will be necessary. As mentioned by Winston Churchill, “However beautiful the plan, you should occasionally look at the results.”

Project Implementation is related to leading and managing the concretization of the project plan: (1) dealing with issues, (2) managing the project team and (3) creatively integrating the different elements of the project plan.

An issue is an unresolved decision, situation or problem that will significantly impact the project and that the project team cannot immediately resolve. Issues management consists of having a process for identifying these problems and managing them until they are resolved. The governance frameworks come into action when unresolved issues need to be escalated to the next level. The project manager needs to be ready to apply resources to address and resolve these issues.

Projects are realized by teamwork. For this reason, project managers are only able to achieve their goals as a result of the commitment, cooperation, and contributions of the people on the project team. As a result, managing people can become the project manager’s most important, and most difficult, job. Most often, when we think of project managers who are especially good at managing people, we tend to focus on their mastery of “soft skills” of people management. These are the project managers who are especially effective at motivating team members, communicating vision, empowering staff, recognizing achievements, listening, leading by example, resolving conflicts and building trust. This does not mean, however, that there are no “hard skills” involved in people management. A comprehensive project plan will not rely solely on the interpersonal skills of the project manager but will also include concrete activities such as organizational charts, job descriptions, acquiring staff, team development, performance assessments and communication norms.

The third focus of project implementation is to oversee the valuable assets that have been allocated to conduct the work of the project and bring all the fragmented work together. To assist with this challenge,
internal control systems should be put in place to provide reasonable assurance regarding the responsible use of project assets.

The ability to successfully execute projects is what drives the realization of intended benefits and the achievement of business strategies. Organizations that execute projects successfully employ effective project management practices as a tool to drive change and achieve business objectives. Given the strategic impact that projects have on business, organizations must follow effective project management processes that measure progress and risks and ensure the right projects can be delivered in alignment with organizational priorities.

**Project Monitoring, Evaluation and Control** – Despite all the efforts to plan exceptionally well, events may happen or change that cause projects to derail. This is where sound, effective monitoring, evaluation and control prove to be worthwhile. The purpose of monitoring, evaluation and control is to provide an understanding of, and to communicate, the project’s progress. Identifying when a project’s performance significantly deviates from the plan enables corrective actions to be taken.

Progress monitoring tracks information about the operational work of the project. It is a passive process, gathering information but changing nothing. It tells the project manager where the project is. Evaluation tends to focus on tracking progress at the higher levels analyzing project outcomes and contributions to its ultimate goals. Control involves establishing the systems and decision-making process to manage variances and the realities of project implementation. It also involves establishing how project variances and changes are managed, documented and communicated to stakeholders. It is during the monitor and control process that we keep abreast of project progress, the quality of our efforts, identifying deviations, determining the necessary corrective action and implementing those corrective actions. The integrative nature of project management requires that monitoring, evaluation and control interact with the other five phases of the PMD PRO life cycle.

Nevertheless, most of the monitoring, evaluation and control targets the plans developed in the form of baselines for schedule, cost, scope, quality, and risks. This enables the project manager to take decisions necessary to manage changes. These actions often require revisiting and revising the original plan. The project logical framework is the first step in developing the full monitoring and evaluation plan for the project. The indicators and means of verification that are included in the logical framework will ultimately become the building blocks for the full monitoring and evaluation plan of the project.

Three evaluation approaches that are extensively used in the development sector are the final evaluations, mid-term evaluation, and ex-post evaluations. Final evaluations are often mandated by a funding agency or required by a development organization’s policy, and would be conducted towards the end of the project. Common evaluation questions might include:

Did the project succeed at accomplishing the outcomes, goals and impact desired? Was the project relevant, effective and efficient? Mid-term evaluations offer the advantage of answering many of the same questions posed through final evaluations, but also provide the opportunity to supply suggestions to improve the project efficiency and impact while the activities are still underway. Ex-post evaluations examine project impact at a defined period after project completion, sometimes a year after the official
close of the project.

This phase also provides information to support status reporting, progress measurement, and forecasting. It is also important that implementation of approved changes is monitored when and as they occur.

**End of Project Transition** – The temporary nature of projects differentiates them from normal business operations. In the development field, however, one often finds projects that have been in operation for years – with one phase of the project continuing the work of the previous phases. This observation underscores the reality that development projects are dealing with social interventions, observation of the lessons learned resulting from these interventions and to look for a new stage of intervention. As such, development projects may be more characterized as evolving degrees of changes with transitions in between, i.e., the end of a project in the development sector is often more accurately characterized as a transition to another degree of social intervention rather than a strictly defined project closure. Change is external and situational while the transition is internal, the psychological process people go through to come to terms with the new situation. Change must start with the individual who will cause a rippling effect on the social area under intervention. As mentioned by Leo Tolstoy, “Everybody thinks of changing the world, but no one thinks of changing himself.”

The development sector considers transition especially important because of their concern that impacts be sustained after the project has ended. Unfortunately, while project transition is of great importance, it is often overlooked and/or under-resourced. With pressures to move on to new projects and reassign staff members to other activities, the most practical way to ensure a complete project closure is to include it in the project plan.

Even considering the transitioning nature of development, the activities that need to occur at the end of a project, include (but not limited to) confirming the deliverables with beneficiaries, collecting lessons learned, and completing the administrative, financial and contractual closure activities. All these must be carefully planned and executed. As a project enters its end, the project manager should contact the internal and external stakeholders (including the Project Board or the Project Sponsor) to verify that the scope of the project has been accomplished and that the deliverables are accepted.

It is important to ensure that the lessons learned are adequately detailed, and are filed and easily accessible. The project manager must distribute the lessons learned to those who can benefit from them. Without a system to capture the project learning, the organization will perennially reinvent the wheel each time a decision is made to pursue a similar project. Donors are often interested in ensuring that learning is disseminated throughout the sector to ensure that new projects benefit from learning generated by other projects they have funded.

Finally, some project teams celebrate the accomplishments during project development and at its end, while many others do not. It is important to have a culture that acknowledges efforts and accomplishments. In the words of psychologist Frederick Herzberg, “True motivation comes from achievement, personal development, job satisfaction and recognition”. A little appreciation expressed by co-workers, a project manager or upper management can be an important positive factor for project teams and can make the project environment more enjoyable. It is incumbent upon the project manager to encourage a
project culture that incorporates an appropriate amount of recognition for individual and team accomplishments.

CONCLUSION

Most international assistance provided by governments and NGOs to developing countries is provided via projects. Despite the importance of effectively using the scarce resources for this sector, limited attention has been devoted in the literature to best practices, approaches, and management techniques in the sector. The broad nature of PM methodologies indicates that different contexts must reflect the specificities of each sector (Golini, Kalchschmidt & Landoni).

This paper advocates that social and humanitarian projects adopt a complete methodological approach and a well-defined and standardized life cycle. This approach ensures that interdependencies are identified and planned for, and project risks reduced. Through adopting PMD PRO a number of major benefits can be accomplished: better risk management through decision gates along the life cycle phases allowing for the continued project justification or even its abortion; proper allocation of roles and responsibilities to the project team; stakeholders to complete the project activities in each phase with the ultimate objective in mind; benchmarking since a common frame for measuring performance is in place.

Donors give millions of dollars each year in grants to NGOs. When grant recipients use project management tools to deliver on time and under budget, they create better outcomes and, in turn, a better return on every dollar resulting in efficacy that permits more to be accomplished with the same resources.

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Proposal of improvement of Coherency of Information in the BIM - Case Study – Dwelling works at Portugal

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ABSTRACT

The efficiency of the AEC impacts in many dimensions, as consumption of materials, profitability of construction processes or capacity on delivering a design with quality. The scope of this research is geared for this last aspect. A quality design was understood as a compilation of the work developed by several disciplines in which there were drawings and written parts that could translate with few errors as possible the object to be built. New requirements, the growing number of agents involved and the maintenance of the current work practices led to improved difficulties on delivering designs with the intended quality. The present paper aims to present a proposal for design development that could help the design team to integrate processes, improve the mutual understanding and the desired data to be produced and foster the information exchange towards an improved knowledge management and the implementation of a design to maintain philosophy. The framework will be tested on a real case study. One of the most critical aspects of the industry is the ability of the agents to adapt and follow the new practices. Following the lessons learned from training actions, the methodology was structured using the current tools and processes already used by the industry and introducing new tools and information requirements that replace or imply little changes on the global practice. These “disturbances”/new processes are framed with the benefits obtained in order to get the agents mobilized for the change. One of the benefits is the reuse of information through the development of information/data that can be reused on other tools through systems integration or transfer systems.

The case study used to test the proposal is the BIM design of a set of plumbing and central vacuum infrastructures related to a single family house. This design was recently implemented and following the investment and BIM applicability, many other similar designs will be applied on the following years with few differences of procedures. Therefore, it is a very good example to introduce the new changes, to be presented on training actions and to test the use information provided by the traditional CAD methodology.

Keywords: BIM implementation, Information and Knowledge Management

1 INTRODUCTION

The efficiency related with AEC industry is influenced by various factors that can be related with material consumption, the processes applied and the capacity of delivery a design with quality and in time.
Design procedures and techniques have been experiencing fast changes with the increase in technology and concerns about sustainability. Nowadays a great number of actors in construction, together with environmental concerns and with the concept of lean construction there is a great focus on improving the profitability through the waste management in AEC industry.

The development of information technologies is drastically changing how the different AEC actors work in the design phase. Traditional CAD design techniques are being upgraded with the use of building information modelling (BIM) which is being increasingly associated with the accomplishment of design quality.

As many design specialties use BIM as a working concept the various software vendors developed different packages associated with the specific needs for each specialty. As there are many BIM software packages there are many options for proprietary formats, and this leads to increasing concerns with the topic of interoperability to achieve a good and correct communication between the different actors involved in the design phase. The issues with the interoperability together with the training and procedure implementation needed by the different actors must bring advantages in terms of waste mitigation on the final design.

This paper explores the BIM concept used in a case of study based on a single-family house designed by the architects Filipe Moreira da Silva, Joana Restivo and Inês Pimentel. The case of study explores current BIM procedures used under Revit software package that enables designers to work under standard rules and methods within the software, enabling a more direct communication between the different actors. The procedures explored under Revit software are related to the interoperability between design specialties, interoperability in the creation of parametric objects, the design of MEP project and also tools used in Revit for quantities take-offs as part of the cost estimating process. This paper explores also the benefits that can be achieved with BIM concept.

2 STATE OF ART

2.1 Design phase

The design can be understood as a work of graphic and written representation composed by many disciplines that resembles as close as possible the object to be built. It is crucial that processes can be integrated by the different agents involved in order to improve design efficiency and mutual understanding of the different drawings and written pieces produced during design phase.

Design is acknowledge as being a very important phase since it’s a central point that will influence the building life cycle. Many costs are related with waste produced during design phase depending on the procedures adopted. Inadequacies that are produced during design phase are many times revealed only during the construction phase, and this is a fact that leads this phase to a crucial role in the whole construction process.

As observed by Rounce (1998) the design faults can be caused by:

- Misinterpretation of client needs;
• Poor communications between designers;
• Using incorrect or out of date information;
• Producing inadequate specifications;
• Misinterpretation of design standards;

There has to be a mitigation of the previous causes in order to increase the profitability of any design.

The concept of BIM is still on his young age of development although is acquiring space under many specialties in construction industry. BIM implementation is enabling increasing communication and systematic procedures by all involved agents. Ideally if all BIM procedures can be correctly systematized and implemented by all agents, the design phase can enter in a cycle of improvement by increasing profitability (figure 1).

![Figure 1 Cycle of improvement (Rounce, G.)](image)

### 2.2 BIM concept

The concept of BIM as not yet find a definition commonly accepted, although there is a common agreement that it is a virtual representation of real characteristics of the object to be build or managed. As it was observed by Eastman (2011) six characteristics can be also mentioned in order to fully define the term BIM:

- Digital;
- Spatially represented (3D);
- Quantifiable using measurements;
- Easily understandable;
- Accessible via an intuitive interface;
- Durable during the lifelong of the building;
The concept of BIM creates a virtual representation of the object to be built, being this representation formed by parametric objects, quantifiable in a way that enables the planning of the different works that exists in the real physical object. One idea developed under BIM is enabling all the different designs to exist in a unique form being related to a single virtual reality where all actors can establish communication throughout this reality.

BIM can have a wide use when considered throughout the entire life cycle of a building. When applied to all building life cycle, BIM constitutes a separate reality, like a mirror of the physical one, enabling the planning and managing of everything that can happen in the physical building.

2.3 Definitions used in BIM

Whenever BIM concept is applied, actors must share a single language and understand each other when they are talking about the different concepts involved. Communication must be established with all agents being able to understand all definitions and specific jargon involved under the different software packages. Different definitions can be understood with slight changes that can evolve to gigantic gaps in communication enabling the confusion and misunderstandings that can cause BIM implementation to be unproductive and unsustainable.

2.3.1 Parametric objects

To explore BIM concept it’s necessary to clarify the differences between 3D and BIM and this difference is only possible when parametric objects enter on BIM concept. Parametric objects enables users to associate information to what is represented in 3D geometry and also to manage this information in the desirable direction. A parametric object as observed by Eastman (2011) has to gather a set of characteristics in order to be possible to establish a difference with a simple 3D object. These characteristics are:

- A defined finite 3D geometry spatially represented;
- A set of parametric associations in order to automatically change their geometries when the user changes values or coordinates in the model;
- Defined hierarchical levels;
- The impossibility of virtually changing some characteristic when the object is impossible to change under the physical world;
- Being able to establish interoperability between themselves and between other software packages;

2.3.2 Interoperability

Interoperability is another term that must be defined and acknowledge by the different actors, this concept is the ability for managing, exchange and communicate digital information by the use of computational methods. Interoperability as became one of the most important concepts since a full interoperability is hard to achieve when implementing a design in BIM, mainly when the different design specialties use different software packages. In the recent years the concern of achieving a full interoperability that enables a full communication has been explored by the development of a proprietary format called Industry foundation classes (IFC). This proprietary format is an open source format that enables the share
of geometry, information and hierarchical relations between the various parametric objects that constitutes the BIM model. IFC has become a way of erasing waste during design phase by enabling specialties the usage of a common language of information. For example, this enables the MEP designer to be able to start his design without having to redesign the architectural features already produced by the architect. IFC also enables companies to create their products as parametric objects and provide them online for being used by the designers. This can be seen as a marketing strategy for the companies but is also becoming a lean way of working. The use of parametric objects provided by companies enables productivity by erasing time that otherwise would be used by the design team in order to produce that parametric object.

2.3.3 Levels of Development vs Maturity Levels

The creation of parametric objects and their exchange between companies and design specialties require a good understanding of levels of development concept. Levels of development must not be misunderstood with maturity levels. According to BIM forum (2013) level of development (LOD) is a reference that enables practitioners in the AEC industry to specify and articulate with a high level of clarity the content and reliability of Building Information Models (BIMs) at various stages in the design and construction process.

Since BIM implies the definition of exact quantities it’s crucial to define different levels of rigor for remove the possibility of finding interpretation errors causing waste in design review and delays. There are 5 levels of LOD (figure 2), all these levels correspond to a certain type of information that must be associated to the object. Higher the level, higher the information knowledge about it, however it can be counterproductive to use a higher level of LOD when it’s only necessary a lower one. As already been observed by Choi et al (2015) it’s necessary to define the scope of information required.

**Figure 2** Levels of development (AIA, 2013)
Maturity levels range from 0 to 3 establishing a scale of collaboration levels under BIM.

As is showed on figure 3 level 0 is the absence of BIM considering only the use of CAD. Level 1 is the use of 2D and 3D platforms with no collaboration between the specialties. On level 2 BIM concepts emerges with the different design specialties separated through different models but communicating with each other. Level 3 is the higher maturity level and it has the name of iBIM by achieving a complete interoperability with full collaborative work between the various agents involved.

**Figure 3** Maturity levels (Bew-Richards, 2008)

### 2.3.5 BIM dimensions

BIM concept is always related with a certain possible dimension that it can achieve depending on the users intentions. When implementation procedures, quantities take-off and schedules are considered it’s important to understand what dimension is being used. As observed by Czmoch and Pekala (2014) BIM can evolve from 3 dimension to 7 depending on the variables that are being considered. The 4th dimension is related the variable time, thus it’s used as a dimension for planning some changes throughout time. The 5th dimension deals with the variable cost and it enables agents to make estimations in real time and also to generate lists with quantities take-off tools. 6th dimension is related with all kinds of physics simulations generated from the original model and the 7th is related with the maintenance applied under BIM.
2.3.6 Software packages available in the market

In order to implement BIM concept, companies need to have access to software packages that have important impacts on the cost of the design process. Usually when a certain company buys a certain software is also buying its maintenance, updates and support. Prices can be very variable depending on the software, number of licences provided and time licence, however it's always an important slice to be considered in the designs total cost. The main BIM software packages derives from the companies like Autodesk that produces the traditional CAD software packages and thus have a long history linked with software development in the area of design.

The main BIM software vendors are Autodesk, Graphisoft, Bentley Systems and Tekla Structures. BIM software packages are acknowledge for presenting lack of strength outside its main area and each one of them present an independent proprietary format, that is the main reason of the concern expressed by designers in relation to the topic of interoperability.

3 CASE STUDY

This paper presents a case study of single-family house in Portugal where BIM concept was applied in order to test the applicability of implementation procedures and exploration of quantity take off tools.

The house presented was designed using both traditional and BIM approaches, thus enabling a more close comparison of the advantages and disadvantages of using a BIM approach. Architectural design of this house was developed by the architects Filipe Moreira da Silva, Joana Restivo e Inês Pimentel. The Architecture design was developed using uniquely BIM approaches under the software Archicad, however the MEP project and quantities take off were developed using traditional CAD approaches. The aim of this paper was implementing MEP design under BIM and establish a comparison between the original MEP design traditionally conceived and the BIM design implementation. This comparison tries to explore the procedures that can lead to a more lean design by reducing waste and increasing profits. The software used to implement MEP project was Revit 2015 and since the architecture used Archicad, interoperability approaches between both specialties were considered.

3.1 Interoperability between specialties

The first challenge in this case study was to find a quick and trustable way of sending all information related to the architecture design from Archicad into Revit in order to start the implementation of the MEP project without having to redesign the architectural parts in Revit software. The interoperability was achieved by IFC format that enabled data transfer from Archicad into Revit. Although this IFC format has been evolved during the recent years and subsequently increasing its quality it has showed some barriers that need to be considered. In tables 1 and 2 are presented the various errors that result on either export from Archicad and import into Revit using IFC file format and the different options associated with it. After the import the design was revised in order to understand if there was major missing parts. The design revision has concluded that no major errors were obtained. The model can be quickly export using IFC format file, enabling different design specialties to use different software to be able to communicate in an efficient way. However after the export is advisable that some time must be spent on reviewing if all kinds of parametric objects are being correctly shared, this include: walls, doors, windows, openings,
roofs, slabs, floors, fixed furniture, and so forth.

Table 1 Errors associated with different interoperability options under export to IFC

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<th>Archicad export into IFC</th>
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<td>Entire Model</td>
<td>Visible Elements</td>
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<tr>
<td><strong>General Translator</strong></td>
<td>Data Exchange with Autodesk Revit MEP</td>
<td>Data Exchange with Autodesk Revit MEP</td>
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<td>76</td>
<td>79</td>
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Table 2 Errors associated with different interoperability options under IFC import

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<th>IFC Import into Revit</th>
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<td>Entire Model</td>
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3.2 MEP design

After architectural design was imported into Revit, MEP design was implemented in Revit. The objective was to fully implement MEP design in order to find out if there is any advantage or disadvantage in the use of Revit for engineering design disciplines.

The commands used in Revit interface were the following: Pipe, Pipe Fitting, Pipe Accessory, Flex Pipe, Plumbing Fixture, Duct, Duct Fitting, and Mechanical Equipment. These commands enable the full design of the plumbing infrastructures of water supply, wastewater and vacuum cleaner system.

All of each command previously mentioned present a standard parametric object that can be modified in order to resemble the real object intended on the design. These modifications can be performed on the geometry, material description proprieties and even related to material and physical proprieties.

If the company of any fixture provides the BIM model of their own product, users can chose to directly import parametric objects previously created by the manufacturer.
The process used for implementing the residential water supply system that is considered to be more efficient is the following:

1. Implementation of all system fixtures;
2. Pipe design considering insulation;
3. Design of the accessory elements;

To complete the design of system fixtures and accessories some elements were modelled inside Revit using parametric modelling, but some were also modelled with Sketchup and then imported to Revit. Every fixture available for online download was considered since there are advantages related to time and better control of the physical and descriptive proprieties if a fixture is created by its manufacturer than created by the designer.

The process used and considered to be more efficient to residential wastewater system design was the following:

1. Design of all downspouts;
2. Implementation of all equipment and fixtures;
3. Design of the remaining pipes;

This order of procedures was considered because it reduces the number of conflicts that can occur between the different parametric objects evolved. This conflicts are mainly related to the slope values that need to be considered on pipes in a wastewater system design.

The final design to be implemented on BIM was the vacuum cleaner system and the procedure that proved to be more efficient was the following:

1. Study of hose's reach and determination of the number of vertical ducts to be used;
2. Implementation of all system fixtures;
3. Design of the ducts;

Efficiency in the procedures followed has been proved by time gained in performing by order the mentioned tasks that otherwise will require more work to be implemented.

The models produced for parametric objects were time consuming specially those previously modelled in Sketchup and then imported to Revit. If for example the user needs to model every single fixture, the design process can have delays which will produce wastage and consequently loss of profitability. Parametric modelling in Revit showed to me more efficient than Sketchup. Although initial parametrization can take more time, when done, every single parameter can be modified in order to instantly change its geometry without having once again to model everything from scratch. During the MEP design it became evident that since a fixture is available on a BIM library it’s advisable to use this fixture in order to reduce waste during design. Thus in this case study were considered some parametric objects previously produced by the proprietary companies. In the absence of one specific fixture already modelled, other standard fixture can also be used and changed by parametrization under Revit.
The implementation of the fixture equipment on the first place proved to be inefficiency only in waste-water system design. This inefficiency happen because downspouts have to be placed in already defined areas for the vertical pipes. Thus when placed after the fixtures, because of the slope values, errors and incompatibilities can be produced under Revit and force the user to place the downspouts out of the already defined spaces.

Figure 4 shows a pipe being designed for the hot water supply system. This figure shows that visualization under BIM is a very important aspect during design and that parametric objects have hierarchical levels and rules associated that play a major role in design and designing visualization.

A very important tool used in this case study was the Type Proprieties tool (figure 5). This tool enables the customization of the many proprieties related to parametric objects. Type Proprieties window enables user to define rules and add descriptive information about an object. Figure 5 displays a selected Duravit sink with all descriptive proprieties that were considered during this case study. Proprieties such as: model, manufacture, assembly code and cost are very important at the time of quantities extraction phase.
Type Properties is very relevant when under pipe design the user needs to define its rules. A pipe system will always have associated unique diameters and unique joints and accessories that are related to that system. In this case study, before pipe design, a standard pipe was edited and modified under Type Properties in order to fulfil all the proprieties and rules in the real physical system.

3.3 Schedules and Quantities

In design phase, quantities are of a great importance and can be defined as written representations of the graphical design. In BIM there are special ways of dealing with the written parts and in this case study it has been explored quantities take-off tools inside a BIM project in Revit.

One of the tools explored in this case study was Schedule/Quantities. This tool enables designers to create a written view of the model in which is possible to select a certain type of objects displayed and its associated proprieties.

Figure 6 shows a schedule extract created from all plumbing fixtures that exists on the model. The fields selected to this schedule were Family and Type, Manufacturer, Level, Count. With the schedule produced the user have quick access to all desirable fields he wants to analyse. These fields can range from areas, costs, diameters, manufactures, levels where the objects are places and so forth. Schedules are automatically created and are a written representation of the model. Any change in one field will automatically produce changes in the model. So if for example, some line of the schedule is erased, the related object in BIM model will also be erased. In the case study schedules were useful for two purposes, to fulfil its use by creating lists of the wanted quantities but also look to inconsistencies present in the design. The schedules created with MEP design has provided precious information that were quickly achieved only with a few steps. This information was used to confirm the number of each object in a certain level, the diameters considered and also descriptive information like the manufacturer, model and cost of each
individual fixture.

Cost estimation of MEP design was performed under Schedule/Quantities tool with only few steps. Any change to the cost of an individual fixture can be modified with Type Properties tool that will automatically change the cost estimation schedule. Schedules/Quantities are fully customizable and can be created to only certain objects or separate water systems and sorting or grouped according to user’s objectives.

4 Case Study Results

The present case study have produced an integration between architecture and MEP design specialties using the 2nd level of maturity in BIM. The final result was achieved as a MEP design in Revit with the water supply wastewater and vacuum system fully implemented in BIM.

Although many possibilities are open under BIM concept there as some disadvantages that need to be
considered and understood in order to better surpass them. The main disadvantages faced during the case study are the following:

- Difficulty during training in learning and understanding the different tools that can be used;
- Difficulties in fully understand and visualize if the interoperability between the software packages used was achieved and the errors produced not significant;
- Lack of parametric objects available online;
- Time wasted in parametrizing the objects that were not created by the manufacturer companies;
- Difficulty in fully understand the concepts and jargon used by different software packages and how these concepts are used in BIM environment;

Despite the disadvantages faced during this case study, many of them can be surpassed if correct training and systematic procedure rules are implemented in the work environment by the various agents. The situation related with lack of parametric objects available online and produced by the respective manufacturers is a problem that cannot be resolved by the design team, however the design team must not waste time creating the exactly the same object with an external software once this can cause wastage during the design phase.

With this case study it has also been showed many BIM advantages that can be extremely useful in order to improve productivity that can lead to increase profitability. Since incorrect communication between the owner and between designers as well as inadequate specifications and standards and out of date information can be appointed as major design faults, BIM can be a very important concept in order to mitigate many of the faults that occurs in the design phase.

The main advantages with BIM in this case study were the following:

- The possibility to create sections, floorplans and elevations that are automatically updated when some change occur in the model;
- The possibility to create quantity take-offs with little effort that are also automatically update when some change occur in the model;
- Quick detection of design errors and omissions;
- Improved communication with the different agents;
- Improved and customizable visualization of the whole design under different views:

During the implementation realized, many sections, floorplans and elevations were created. Revit software enables the full customization of these views, fact that drastically improves the visualization and understanding of the whole design. The user can easily create views with certain types of objects hiding others and choosing between many visualization options.

Errors and omissions can be quickly detected by exploring different views when working on the design, most of the times errors are even adverted by the software.

In BIM, information is constantly being updated in real time within the different views and schedules
generated, this makes impossible for any change produced in a document not appear on the others.

On figure 7 is showed the architecture design previously modelled in Archicad. In this figure is easy to understand the power that BIM enables when the communication with the owner is in question. The design team can show preliminary renders of their design to the owner in order to communicate possible changes in an early stage of the project. The visualization in BIM can be very intuitive and be achieved by many different forms. In order to have a better communication and understanding on early stages, design members can create conceptual designs in BIM with information of the volume, areas, number of a certain type of elements and so forth.

Figure 7 Architecture design (Moreira da Silva et al, 2015)

Figure 8 shows the final MEP design fully implemented in Revit. It’s noticeable by the figure that architecture design is faded and blocked when a MEP designer is working on his specialty. This blocking is important since restrains one specialty to produce changes on the design of any other. In figure 8 its showed supply water system represented in blue and red symbolizing cold water and hot water respectively. It’s also showed the wastewater system in green colour and light blue as well as vacuum cleaner system represented in pink colour.
5 REFERENCES

Impacts of ERP Implementation on an Engineering Company

ABSTRACT
For engineering companies and Brazilian companies in particular, profits and margins are decreasing considerably each year, so it has become crucial to improve cost management as much as possible. The implementation of an ERP system is one of the fundamental steps to achieve this objective. In addition to this, there are other significant issues to address, such as controlling specification and index definition. This study begins with presenting the company’s history, analyzing the resources being used and some of the gaps that were faced with regards to cost management prior to implementation of the ERP. It then describes the implementation phase and the primary goals achieved, presents the structure of the controls necessary and concludes with the main results of this implementation. This paper was developed based on a real Brazilian company founded in 2010 that provides engineering and software solutions for national and international markets, Radix Engenharia e Desenvolvimento de Software.

Purpose of this paper (mandatory)
Analyzes the impact of the implementation of an ERP on an engineering company.

Design/methodology/approach (mandatory)
This study is based on a real case of a Brazilian company (Radix Engenharia e Desenvolvimento de Software).

Findings and value (mandatory)
Implementation of an ERP brings more positive than negative impacts.

Originality/value of paper (mandatory)
This paper is catered to engineering companies and presents a successful case of ERP implementation, analyzing their positive and negative aspects.

Keywords (no more than 5): ERP, Engineering, Impact, Implementation, Radix
1 INTRODUCTION

Just over a decade ago, the implementation of information technology systems in a company, management information systems in particular, also known as Enterprise Resource Planning (ERP) systems, represented mainly cost (Davenport, 2002). However, with the evolution of technology, World globalization and other global aspects, this factor became an investment that effectively leverages and maintains business competitiveness (Norris, 2001).

As observed by Gonçalves (1998), new technologies always cause changes in the social environment of organizations and it is difficult to imagine any technological innovation without any effects. Among the various technologies that have impact on daily work, information technology is one that has garnered more attention of entrepreneurs and researchers for its widespread dissemination in the majority of companies. Due to its relevance, its study is vindicated, exploring the various aspects related to its impacts which can be observed in the implementation of information technology through special ERP systems.

Thus, this paper aims to identify the impacts of the implementation of an ERP system on a Brazilian company founded in 2010 that provides engineering and software solutions for national and international markets, Radix Engenharia e Desenvolvimento de Software.

It begins by presenting the company’s history with an institutional overview, the company’s organizational structure and its main projects. Secondly, it describes the main concepts, aspects of implementation and some advantages and disadvantages of an ERP system. It then shows the ERP implementation phase and its impacts, specifically addressing such impacts on the Radix company. The paper concludes outlining the positive and negative impacts of ERP implementation on an engineering company.

2 COMPANY HISTORY

2.1 Institutional overview

Radix, derived from the Latin word meaning “root” or “origin”, is an engineering and software company that provides technology-based services and solutions, highly qualified and technologically independent, to attend to the main industries and corporations of the World.

Founded in 2010, Radix coalesces various skills into one team, with 25+ years of market experience, building a unique profile in the international market, capable of solving a myriad of technical and business challenges. Its mission is to provide consulting, engineering, automation, and software services differentiated by technical excellence and technological independence, increasing the benefits for its customers, employees and shareholders, whilst maintaining a long-term commitment to society and the environment.

Its vision is to be the best engineering and technology company for its customers and employees, besides being recognized in the international market as one of the main providers of services and solutions for the industries and corporations.
Its values are Long Term Relationships, Focused Individuals, Agility, Challenges, Ethics, Innovation and Commitment.

At its core lies the Consultancy group, which understands the real needs of customers and then designs the solution, combining different skill sets of the Engineering, Automation & Industrial IT and Software Development groups. Each group has a team of experts, well trained in the leading technologies available on the market.

![Figure 1 – Radix’s services](image)

Radix works with several industries and corporations operating in the sectors of: Oil & Gas, Naval, Metals, Mining & Cement, Chemicals & Pharma, Power Generation, Media & Entertainment, Transportation, Finance, Healthcare and Sports.

In 6 years, Radix has already developed 500+ projects in 10+ sectors for 80+ companies.

In early 2015, Radix believed in macro diversification and acquired a new partner to capitalize the company: Sotreq, the largest dealer of Caterpillar products, and also operating with 100% national capital (alike Radix).

2.2 Organizational structure (units, sectors)

Radix operates by applying a broad range of process knowledge and experience in over ten industries. In 2015, they split our services into four business units: Oil & Gas and Energy, Metals & Mining, Agribusiness and Services.
In the same year, their internal support area was split into departments: Infrastructure, Human Resources, Commercial, Controlling, Directory, Financial, Legal, Marketing, Events and Wellness, Quality and Environmental and Information Technology.

### 2.3 Main projects

Radix has developed more than 500 projects, some of them are presented below:

- FEED and Technical assistance, System development of the Interface Management and HAZOP Recommendations Management for 8 FPSO’s (the Replicants)
  - FPSO SCADA system enhancements
  - System development for the construction of riser drawings
  - Detailing design for structures of offshore modules
  - Pilot project with Oracle developed for the Manufacturing Operations Center for Drilling
  - Detailed engineering for the replacement of automation panels for Allen-Bradley FlexIO
  - Automation Support for a clinker production unit
  - Handling System, Inspection and Maintenance of an Arc Furnace and slag pots
  - CFD studies and Quantitative Risk Analysis for gas pipelines and gas compression stations;
  - Electrical studies for panel replacement in control rooms
  - FEED for gas compression stations
  - Engineering Frame agreement for 18 power plants (conceptual, basic and FEED design)
  - Process Information Management System for 18 power plants
  - Conceptual and basic designs for Energy Efficiency in 15 power plants and 3 fertilizer plants;
  - EPC for a Delayed Coking Pilot Plant
  - Detailing Design (incl. 3D Model) for the RNEST refinery Utility plants
  - Detailing Design (incl. 3D Model) for Reform Heater (Fertilizer plant)
3 LITERATURE REVIEWS

3.1 ERP concept

An integrated system is composed of a modular structure (nucleus) in which the company's own settings and a variable number of modules are defined, all dependent on the requirements of implementation of each entity individually.

On the other hand, unintegrated applications represent a set of programs or modules separated or not related to each other. And for this reason, users generally spend a great deal of time repeating the same task and entering the same data in different programs. Many problems are faced as a result, such as information being inconsistent and unreliable because the modules aren't crossreferenced with each other, time wasted by entering the same information repeatedly, inconsistent formatting of identical information in each module, etc.

In order to mitigate the problems listed above amongst unintegrated systems, the ERP systems were designed.

According to Moura (2004), an ERP is designed to provide complete integration of the organization’s business information processing systems.

For Turban (2005), the main objective of an ERP is to integrate the departments and functional information flows of a company, based on the use of a single system that meets the various needs of the organization.

Beheshti (2006) defines an Enterprise Resource Planning (ERP) system as “a set of business applications or modules, which links various business units of an organization such as financial, accounting, manufacturing, and human resources into a tightly integrated single system with a common platform for flow of information across the entire business”.

According to Xu and Yeh (2009), an ERP system is a combination of advanced technologies and best business practices. It enables an organization to achieve its specific business goals and gain a competitive advantage by providing a common platform to integrate all aspects of its business.

As stated by Turban et al (2003), the ERP emerged from systems developed in the 1960s designed to manage production through inventory control, purchasing and scheduling. From these systems, financial and labor controls were then included, thus generating the known MRP systems (Material Requirements Planning).
The table below represents the origin and evolution of business management systems, along with the denominations stated by Turban et al (2003). This author divides MRP systems into two stages (before and after the inclusion of finance and labor modules, and includes the development of the ERP system known as SCM (Supply Chain Management)).

Table 1 – Evolution of Management Systems

According to Koch (2002), an ERP aims to integrate all departments and processes of a company within a single system considering the particular needs of these departments. ERPs replaced financial, human resources, production and inventory systems with a modularized system roughly resembling the isolated systems. The finance, human resources, production and inventory areas continue utilizing their systems, but they are now interconnected, and people from one department can get information from another, improving services overall.

In Brazil, the adoption of integrated management systems using market tools started in the second half of the 1990s after the economic stabilization of the Brazilian currency, and was accelerated at the end of the century due to the consideration of the “millennium bug”.

ERP systems, according to Mandal and Gunasekaran (2003), can bring significant improvements in efficiency for the company, if implemented correctly. In addition, IT systems have a major impact on productivity in both industries and for services providers. ERP systems have received much attention lately for their potential to provide greater efficiency in decision-making.

Many companies are using ERP packages as a means to reduce production costs, increased productivity and added value to their business. Unfortunately, ERP systems can damage a company if it is not implemented appropriately.

3.2 ERP implementation

As Rodrigues and Assolari (2007) state, the implementation of ERP technology allows for the reassessment of processes in order to structure and develop them. If these adjustments are not made, there will be a significant chance of the implementation being unsatisfactory.

The implementation of an ERP system should be planned due to its complexity and numerous modifi-
cations it incites within the company, such as its processes, the way of work, employee responsibilities, etc. The system provides a package with a number of functions that are considered the best business management practices that drive administrative processes.

The impacts resulting from the use of an information system, such as an ERP, occur due to changes in the routines of the company. Employees are faced with a new reality that requires different skills and a dynamic profile for the implementation of tasks. Therefore, training and empowerment become indispensable for the entire company.

Although the failure rate of ERP implementation has been highly publicized, many companies are not reluctant to invest large sums of money on this kind of system, since it is known that the failures are not caused by the incorrect coding of ERPs.

A company needs to allocate a large investment towards the adoption of this system for it to benefit the organization. Implementing an ERP system requires thorough strategic thinking that allows companies to gain a better understanding of their business's processes. An ERP system is a software package that needs to be customized in order to meet business needs. The company does not need to do the development (coding) such as what is needed for a normal information system. When it adopts the technology, the company has to consider the changes that will take place within the organization, such as process changes, technological changes or even changes to the organization's structure. One of these changes relates with the way the company does business: how business processes are affected by the system.

Successful ERP implementation has been influenced by the approach towards the implementation and the organization's maturity level (Dantes & Hasibuan, 2010). Technology is only one aspect involved in ERP implementation that must be considered aside from employees and process changes. An ERP system will have high possibility of success when the organization makes minimum changes to the organization's business processes and used software (O’Leary, 2000).

However, this approach will make the ERP system serve as a support to the current operational structure of the organization rather than create a competitive advantage.

Many companies were not successful after implementing an ERP system. This was not caused by a poor implementation approach but rather because the organization's culture was not ready to adopt the system.

Various factors may influence the success of an ERP's implementation, such as an organization's maturity level, implementation approach, organizational culture, business processes, high-level management commitment and other external factors.

Several authors have similar views regarding the implementation phase, especially its importance to the success of an ERP’s impact on a company. Some of these points of view are presented below.

For Souza and Zwicker (2000), the main difficulties relate to system updates and version management, because even after its implementation, the system maintains a continuous evolution, always trying to
align with the company's processes. Thus, it is observed that the process of ERP implementation within an organization demands both adaptability of the system to the organization and the organization to the system.

According to O’Leary (2000), ERP implementation approaches (BPR - Business Process Reengineering drives ERP) are very risky. But if a company is successful in implementing it, the company will gain optimal benefits as well as a competitive advantage.

Loh and Koh (2004) mentioned the importance of configuration, integration, and user training under uncertainties during the implementation of ERP systems. Problems can arise from software configuration and system module integration errors, communication breakdowns, conflicts between business objectives and ERP system objectives, labor shortage, unskilled personnel, and poor data collection.

3.3 ERP Advantages and Disadvantages

As presented before, ERP systems are crucial for better company management substituting unintegrated applications that were used in the past. The importance of implementation phase and its main keys of success were just described. Now some advantages and disadvantages of using this kind of tool in a company will be presented.

According to Murphy (2002), the benefits of implementing management information systems can be divided into tangible and intangible. Tangible may be defined as those that directly affect the company's results, such as cost reduction and profit generation. Intangibles are those that cause business performance improvements but do not directly affect the company's results, such as information management, security, etc.

From an IT point of view, according to Adam (Adam, 2014), the implementation of ERP integrated systems is difficult and expensive, but the benefits are substantial. While citing Elizabeth Umble, the author argues that the most important benefits would be the following:

- An unified and comprehensive vision of the business, which covers all activities and data flows in the areas/departments
- A database entity in which all transactions are recorded, processed, monitored and reported. This unified vision may require increased interdepartmental cooperation and careful coordination; This ensures improved communication and significantly shorter response times
- An unified system of reporting to generate and analyze real-time data coming from different departments
- The possibility of extending ERP systems with modules that provide functionality for Business Intelligence, enabling the generation of scenarios falling under the “what if” category
- The possibility of integrating other systems existing within an ERP system via APIs (Application Programming Interfaces)

And according to Hurbean (2013), quoting O’Leary, the potential offered by an ERP system for value creation is mostly systematized through the following features:
An ERP system brings together all the activities of the entity, since the processes “crosses” more functional areas.

- ERP systems promise using best practices
- ERP systems are an activating standardization organization
- Integrated ERP systems eliminate information asymmetries
- An integrated ERP system provides information anywhere (online) in real time
- An integrated ERP system offers competitiveness, simultaneously providing the same data for planning and control
- An integrated ERP system facilitates communication and inter-organizational collaboration

This same author states that not all the benefits can be measured. Thus, he believes that there are some quantitative benefits such as stocks, expenditure materials, the reduction of labor expenses and operational costs, sales and cash flow improvement, etc. On the other hand, some nonquantitative benefits are presented such as overall accounting costs. This results in the reduction of work time for accounting and financial reporting.

In summary, some advantages of ERP systems are listed below:

- Safe integration and secure access to information, reliable information quality
- Standardization of business processes
- Automation of business processes
- Development of enhanced managerial decision-making
- Eliminating data redundancy and operations
- Reduced delivery time
- Cost reduction
- Easy adaptability
- Improved scalability
- Easy maintenance

And some disadvantages:

- Substantial financial investment
- Long periods of deployment
- Difficult and complex implementation
- Inflexibility and vendor dependency
- Rigid hierarchical organization
- The existence of hidden costs
- The need for expansion and further development of the system
Many trade entities, especially those that are medium-large sized, have implemented integrated ERP systems. As Hurbean (2013) states, practice has shown that it is not so difficult to implement an integrated package of applications, as well as to benefit from all the advantages that they generate. This is partially due to the complexity of ERP systems, as well as misunderstanding principles of working at a managerial level. In addition, the optimal operation of the system is only possible through harmonization with insight into the daily functional entity.

4 DISCUSSION AND RESULT

4.1 ERP implementation phase

Following Radix’s founding, the partners understood that the company needed a system to control its financial, tax, accounting and human resources departments. As the Brazilian market had many systems, a system was identified that would not require a large investment and that also met the initial business requirements, but this system wasn’t an ERP and lacked integration between modules, as shown in the figure below:

![Initial configuration of Radix’s system (non-integrated)](image)

All controls were processed in Excel spreadsheets since the system didn’t have integrated modules and reports that met the requirements of company management. These factors caused many difficulties such as:

- Multiple Databases
- Difficulty in decision-making
- Lack of information control
- Lack of real-time information display and integration
- Multiple entries of same information required
Due to all the issues given above and particularly the third factor listed, caused primarily by the lack of an ERP system in the company, it was crucial to search for a complete tool that permitted the integration amongst all finance processes.

Besides the need for urgent improvement, as Davenport (2000) stated, quoted by Platt (2004), companies that have adopted an ERP system, expect it to return some results, among them are:

access to information in real time, reduction of management structures, control of information centralization and standardization processes, including the standardization of administrative practices to geographically distant companies, unifying the culture and control of the company.

And according to Huang and Newell (2003), a growing number of multinational enterprises are beginning to embrace ERP systems with the anticipation of increasing productivity and efficiency, and also as a means of leveraging organizational competitiveness.

Thus, with the change of company shareholders at the end of 2014, the new partner that uses the biggest ERP tool on the market suggested that Radix start using the same system. As a result, Radix decided to implement its first version of that ERP in March 2015.

In this section, the main aspects of this implementation process will be described, particularly the most important issues and achievements, including a version change during the implementation phase.

The implementation took place in two phases. The first phase took place right after the change of shareholders, using a version that was already in operation by a partner. The second occurred after updating the version of the ERP system.

In the first phase, some modules were from the main supplier and others were from third-parties. However, all of them were fully integrated.

Since the system was implemented after the start of the fiscal year, only the balances of financial accounts were migrated to the new system. Therefore, detailed releases were not transferred to the ERP.

During the second phase continuing on from the initial release, all the modules from the original vendor were deployed and all data from the previous version was migrated.

Throughout both phases, training was provided on the job with little to no formal instruction.

Since the ERP system project had already begun before Radix began using the ERP, many of the settings and entries were eventually made after system deployment. This represented probably the biggest problem of the implementation phase because Radix's requirements could not be considered in initial phase.

In summary, there were several difficulties during ERP implementation, such as:

- Accessibility problems – since a complete survey concerning the needs and profiles of Radix's users was not created, many people began ERP usage without adequate access. This significantly delayed
the initial phase

- Training – considering that the training wasn’t formally conducted, many problems were faced during system operation. Users were forced to learn from other users or through consultancy support

- Scope not considered – since Radix was not directly involved in the initial requirement gathering process, many features were not initially contemplated thereby causing delays in system usage

- Data migration – in the first phase, data migration occurred in a simplified way, i.e. only the balances of the financial accounts were transferred. On the other hand, all entries had already been migrated during the second phase based on the previous version. Thus, during the external auditing period, the data collection was based on legacy systems (before ERP) which caused additional difficulty to the auditing process

- Data integration – the primary accomplishment of the ERP’s implementation was the integration of the various modules with subsequent data integration. Thus, it became possible for the data to be entered in a single and consistent manner, as well as being available to all modules

- Information Security – an ERP naturally allows for greater access security and therefore an ideal segregation of data, in addition to allowing complete traceability

- Structuring of processes – with the implementation of an ERP, it is natural that all processes defined by the company are ensured, since the data input will essentially follow all company procedures.

4.2 ERP impact

Due to having a non-integrated system before the implementation of an ERP, the company had very few controls which were mostly performed in Excel.

Aside from the difficulty of keeping them up to date due to the need to manually input the information into each module, the systems had neither the minimum capability nor sufficient reliability to make the required decisions.

Around the same time, the company did not have a structure of business units or cost centers that allowed for the segregation of revenues and expenses, and as a result, all controls were generated on a consolidated basis, which made analysis by the company’s management difficult.

There were neither structured processes nor integration between the different departments.

For the reasons listed above and further confirmation by Turban (2005), it was essential to urgently implement an ERP system.

With ERP integration, the existing processes used by the shareholder company were deployed and business units were created (item 2.2). A centralized cost structure was defined and a single accounting plan
for all group companies was created. With this, all entries were integrated allowing for any level of analysis, consolidated or detailed.

As Mesquita (2000) states, a company that has gone through a successful implementation of an ERP starts to move towards the result, and everyone goes to work for the process. An ERP system somehow eliminates the barriers between departments, making the flow more responsive and transparent in addition to standardizing information. People start to worry about the outcome of the process, rather than just worrying about the performance of their individual tasks.

Thus, after the implementation of the ERP, Radix began operating according to defined processes (standardization of business processes) while following security procedures (safe integration and secure access to quality information), having only entries that satisfy all modules (eliminating data redundancy and operations), and begin taking advantage of the many benefits of an ERP system.

Other gains have been achieved, such as reporting and standard queries, traceability of information, visualization of results by BUs (Business Units) and/or cost centers (projects) and others.

As Radix entered the ERP project at a later stage, after its operation within other companies of the group, it did not experience some of the major disadvantages of an ERP which can be highlighted:

− substantial financial investment - the cost of implementation had already been taken care of by other companies, leaving Radix with only a monthly contribution to use the tool.

− long periods of deployment - the same occurred with implementation time. Radix went through this process very quickly.

However, other factors were experienced by Radix, such as:

− the need for expansion and further development of the system - Radix had some peculiarities in comparison to other companies which caused the need for customizations that delayed the release of certain functions

− the existence of hidden costs - due to internal process changes, Radix had far more direct processes which generated additional team costs.

After the completion of ERP implementation at Radix, the phase of improvements to appropriations and controls began.

Revenues and expenses were entered into cost centers and accounting accounts which were not always fair and adequate, thus causing some distortion in reports and consequently in analysis. As there was no supervision of these appropriations, there was a concern that the releases were the most accurate.

With the entry of a CFO at Radix, some actions were taken to improve these appropriations and therefore the controls as well. First, a list of significant accounts was created with their respective examples in
order to facilitate identification by multiple users. The same was done for various cost centers.

In addition, there have been continuous explanations concerning the importance of appropriations being the most accurate possible so that reports and controls represent the reality of the company. Only in this way could further analysis and decision-making be made accurately.

In parallel, it began an ongoing surveillance for all the appropriations, providing the ability to request adjustments when necessary.

In another step, they began to split costs. Many corporate expenses were entered in a unique way within certain cost centers, especially those relating to the corporate area (overhead). Thus, distortions were generated in the analysis because certain areas had better results than others since they did not include parts of administrative costs, for example. This problem was solved steadily following the split of common costs.

After a few months, the appropriations began to be made appropriately, generating greater reliability of the results presented in various forms throughout the company's management.

Thus, Radix came to precisely see all the results of each BU and each cost center associated with a correct appropriation of income and expenses after the implementation of the ERP. Thus, it began to better manage its resources.

5 CONCLUSION

This paper's objective was to identify the impacts of the implementation of an integrated management system known as an ERP in a medium-sized company within the engineering sector, analyzing the electronic history of the company, its implementation of an ERP and its consequences.

The implementation of an ERP generated both positive and negative impacts for the company. As for the positives, it can highlight the interactions between the various sectors, give way for more skilled work, increase agility and improve processes, quality and clarity of information to help in decision-making. Among the negatives, the lack of staff available for training becomes apparent, the duration and form of the training, dependency on technical support, and inability of the software to meet Radix's specific requirements.

Therefore, we can conclude that although the system has a high cost and makes the company somewhat dependent on specialized consultants, the ERP allowed for better allocation of resources, organization of the company's sectors, agility in data transactions and competitiveness in the market.

One important point is that the ERP system itself is necessary but not sufficient to improve cost management in engineering companies. It's fundamental to have an adequate central cost structure, correct cost appropriation and well-customized reports that present a good vision of company results.

However, it is remarkable that this paper does not exhaust the subject, but rather raises further questions about the implementation of management information systems. Like this paper, new research can
address the perception and reaction of individuals to technological changes, the measurement of financial gains arising from the adoption of new technologies, and the relationship between technology and competitiveness.

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The Cost of Being Green: Case Study of a Certification Methodology

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ABSTRACT

The Brazilian construction industry accounts for about 6.5% of the country Gross Domestic Product. The great capacity to generate jobs, and the movement of a large sum of money in investments for the realization of projects directly impact the national economic scene. Unfortunately, it is also responsible for an intensive use of energy, the consumption of significant amounts of natural resources, much of the carbon and greenhouse gas effect in the atmosphere, as well as being the main generator of waste among all productive activities. Therefore, the adoption of strategies aimed at minimizing the environmental impacts caused by construction is peremptory. This requires breaking some paradigms associated with the theme, such as the culture that sustainable works are expensive and restricted to high-end buildings. On that basis, as a way to encourage companies to adopt more sustainable construction techniques were created the certification processes, attesting that a particular enterprise was built according to defined social and environmental criteria. Among the various existing assessment methods, the “Casa Azul” developed by the “Caixa Econômica Federal” bank, was the first facing social housing, and on which there are still few studies conducted. The purpose of this paper is to evaluate the cost of retrofit of a multifamily residential project, so that it meets the minimum requirements to obtain the maximum gradation of this certification system. Therefore, it was decided to carry out an experimental research where a team consisting of an engineer and an architect adopted a real project seeking to meet the largest possible number of established criteria in order to reach the required score for the certification achievement. The modified project was budgeted and their costs were compared with the original budget. The results indicated that their initial expense for the certificate project was higher, however, it was estimated that in the medium and long term this development presents economic advantages, such as lower power consumption, high water savings rate and reducing the amount of waste generated. Finally, it highlights the importance of this kind of analysis once the determination of the impact generated on the environment by certain building should not only consider the construction period, but its entire life cycle, from conception to demobilization.

Key-words: Construction industry; Sustainable buildings; Certification program.
INTRODUCTION

Since ancient times the construction is present in human history to meet their basic needs. But, initially there was no concern about the optimization of resources used in construction. As the branch directly impacts the economy of the countries through employment and investment, there was the development of the sector and a fall in the availability of resources was necessary to brush up the techniques of building and addressing sustainable character issues due to excessive use of energy, water, materials and emissions of greenhouse gases caused by branch.

In this context, there were mobilizations at national and global level to discuss environmental issues in construction. With the growth of discussions on sustainability in construction, organizations, entities and councils were created to manage it. These bodies have developed certificates to encourage sustainable practices and evaluate the impact generated by the building.

Environmental certificates began to be developed in the 90s with purpose to change the mentality of business processes in construction. As it is recent there is a great difficulty to the implementation of this idea because the construction is a branch that handles high investments that usually brings positive return to investors without certificates thus there is a fear to follow this guideline sustainable. Among the various national and international certifications of evaluation of buildings, stands out the Casa Azul Certification which is a seal designed for residential buildings. Like other certifications are analyzed criteria that generate the degree of environmental impact through grade levels that is generated by housing.

Sustainable construction aims to reduce the environmental impact with integration of production processes since the stage of obtaining and manufacturing materials, during the project execution, to the life of these materials and systems. Among the processes, rationalization of energy use is highlighted, reuse and use of rainwater, reducing waste and recycling.

Today, amid the Brazilian economic crisis is also important to highlight the economics side of sustainable construction, the high cost to the implementation makes sustainable projects are denied. However, it is noteworthy that the cost of sustainable construction is not synonymous with high cost compared to conventional buildings. The initial cost tends to be higher for the implementation of sustainable project, but it is estimated that this increase will be diluted over time through the watersaving project, energy and waste generation.

1 SUSTAINABILITY CHALLENGE IN CONSTRUCTION

The construction industry has always been present in human history and there was no concern about the optimization of raw material to be in a huge abundance in nature. For years this concern was ignored and according Moreira (2013) only in 1987 by the Brundtland Report the theme of sustainable development related to construction was introduced worldwide. The Brundtland Report or “Our Common Future”, as it was named, is a document prepared by the UN World Commission on Environment and Development (UNCED), which had the purpose defined as one that meets the needs of the present without compromising the ability of future generations to meet their needs. The document highlighted the main environmental problems proposing sustainable solutions. (MOREIRA, 2013 apud CMMAD, 1988).
Currently it is given much more attention to this issue and a number of surveys are conducted for the impact size of the data that this industry generates in the world. The International Building Council (CIB) says the construction is responsible for the largest consumption of natural resources and use of energy on a large scale (MMA, 2013). Moreover, in cities large and medium-sized estimated that more than 50% of municipal waste that are generated by human activities come from the construction industry (JACOBI; BESEN, 2011 apud SINDUSCON, 2005), making this sector a major offender to the environment.

Sustainable construction is a concept that can encompass any type of building. To have a sustainable building is important identified all processes that impact on the environment during construction and use of the building. The building becomes sustainable when developed solutions to ecological problems that meet the customers and the environment. For growth of sustainable buildings is important that these actions have technical, environmental and economic viability.

With the subject of sustainable construction gaining momentum emerged several entities, organizations and councils in various countries to generate and disseminate sustainability practices in construction. The CBCS (Brazilian Council for Sustainable Construction) is a Brazilian agencies that collaborating in this business which was established in August 2007.

The cost of a sustainable construction may be or not higher than a traditional construction by taking into account factors such as location of the work and the degree of sustainability. According to the elaborate project the cost can reach only an increase of 1% to 5% higher than a conventional building (MANFREDI, 2009).

In order to be successful on the issues of sustainable construction it is important to do an interaction of all processes that affect the environment, from extraction of raw materials, transportation of materials, execution, maintenance, energy use, water, waste disposal until the demolition after the end of its useful life.

2 ENVIRONMENTAL CERTIFICATION IN CONSTRUCTION

With abuse and a considerable drop in the availability of natural resources for construction, the world saw the need to worry about the environmental issue in the world. From the initial discussions and demonstrations on the environment, many countries have established councils and organizations that address issues of sustainable practices, propose certain requirements and develop evaluation methods of environmental impact of construction.

As the construction industry has a great history of consumption of materials, water, energy and greenhouse gas emissions, is of utmost importance to be adopted methodologies for effective utilization and less impact to the environment. Based on this, environmental certifications for buildings that indicate the level of sustainability of the project were developed.

Currently, system of eco-labels have been developed to the sector in several countries. Among the certificates that have greater prominence on the world stage we can mention the LEED (Leadership in Energy Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method)
and CASBEE (Comprehensive Assessment System for Building Environmental Efficiency). Besides these, made it necessary to create a large number of certificates because the reality of the countries are very different.

The LEED is a system of guidance and certification of sustainable buildings created by the US in 1993 recognized worldwide that aims to encourage the transformation of buildings and construction focusing on sustainability. According to GBC Brazil (Green Building Council Brazil) (2013, apud S.F. SILVEIRA, 2014, p. 30) this system is used in 143 countries and in Brazil it was introduced in January 2008 (VALENTE, 2009, p. 30). LEED is divided into points tracks that are obtained through obeyed requirements, some mandatory and some elective, which quantifies the degree of impact caused to the environment by building constructed according to Table 1:

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>52 to 69</td>
</tr>
<tr>
<td>Gold</td>
<td>39 to 51</td>
</tr>
<tr>
<td>Silver</td>
<td>33 to 38</td>
</tr>
<tr>
<td>Certification level</td>
<td>26 to 32</td>
</tr>
</tbody>
</table>

Source USBGC, 2009

The BREEAM is considered the internationally pioneering system in environmental performance evaluation that was developed by the United Kingdom in 1990. In the evaluation, the buildings may fall in the categories “Pass”, “Good”, “Very Good”, “Excellent” or “Outstanding” according to the score (JAGGER, 2011, p. 2-3). Currently, this process is not widely applied in Brazil and some of the required criteria can not enable the construction due to the different reality of Brazil and where the system was developed.

The CASBEE is a system that was developed in Japan in 2002 that is aimed at evaluating existing buildings and new buildings (VILHENA, J.M. 2007, p. 60). Like other certifications, it also has its updated parameters according to the evolution of new methods of sustainable construction. The evaluation is to analyze the balance of impacts by building generating a rating ranging from increasingly better qualification C, B, B+, A, S (higher) (JAGGER, 2011, p. 9).

Since global awareness and action in respect of sustainability in the construction industry the Brazil felt the need to develop their own eco-label system to measure and also encourage sustainable construction. At the national level the main environmental certifications are: Procel Edifica, AQUA, Qualiverde and Casa Azul.

In 2003, it was established the National Program for Energy Efficiency in Buildings by ELETROBRAS / PROCEL – Procel Edifica. Before its creation, PROCEL was working for the rational use of energy in construction, but with the establishment of Procel Edifica had an enlargement would of shares in the efficient use and conservation of natural resources in buildings. According to this organ about 45% of billed
consumption in Brazil corresponds to the electricity consumption in construction. Believes that with the implementation of this certificate can halve consumption for new buildings and 30% for buildings that enter the parameter of this certificate. Subdivided into 6 categories evaluation Procel Edifica offers incentives and project financing in energy efficiency area (PROCEL INFO, 2016).

The process AQUA (Enterprise High Environmental Quality) is the Brazilian adaptation of the French label Démarche HQE (Haute Qualité Environnementale) created by Certivéa body. This certificate was developed by USP professors and created in 2007 by Vanzolini, which has 14 criteria subdivided into 4 categories that meet ecoconstrução, the eco-management, health and comfort aiming to provide economy of light and water, waste disposal, quality of life, among others (RODRIGO; CARDOSO, 2010, p. 1-3).

The Qualiverde qualification was developed by the Municipality of Rio de Janeiro with the Compur (Municipal Urban Policy Council) in 2012. This type of certification is valid for commercial buildings and homes in general both for construction and for reform. Like other certificates the Qualiverde follows a criteria line subdivided in the following categories: water management, energy efficiency, thermal performance and design. Given the proper criteria can obtain a number of tax benefits and edilícios as a way to encourage the use of the certificate (BEZERRA; OLIVEIRA, 2015, p. 43-49).

It is noteworthy that despite variations criteria, guidelines and requirements that can be updated by the system to obtain the certifications, they all have as main objective the environmental incentive as the rational use of natural resources, reducing energy consumption, water, waste and greenhouse gas emissions construction.

.3 CASA AZUL CERTIFICATION

The Casa Azul Certification was created by Caixa Econômica Federal in 2008 and acts in residential buildings. This certificate has three levels of classification: gold, silver and bronze. There are 53 criteria divided into 6 categories of urban quality, design and comfort, energy efficiency, conservation of material resources, water management and social practices. To achieve the minimum grade (bronze) the project must fall into 19 mandatory criteria, for classification rise to the silver level just meet the required criteria plus an additional 6 criteria of free choice. For maximum rating, the certification Casa Azul gold, must possess the required criteria plus an additional 12 criteria of free choice, that is must meet 31 criteria of the 53 existing (JOHN; PRADO, 2010).

Subdivided into categories is shown in Table 2, the criteria required for the bronze level certificate:
Table 2 Mandatory criteria divided by categories.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Mandatory criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Quality</td>
<td>Quality Surroundings - Infrastructure</td>
</tr>
<tr>
<td></td>
<td>Quality Surroundings - Impact</td>
</tr>
<tr>
<td>Design and Comfort</td>
<td>Landscaping</td>
</tr>
<tr>
<td></td>
<td>Place for Selective Collection</td>
</tr>
<tr>
<td></td>
<td>Leisure, social and sports equipment</td>
</tr>
<tr>
<td></td>
<td>Thermal performance - Gasket</td>
</tr>
<tr>
<td></td>
<td>Thermal performance - Orientation to the Sun and Wind</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>Low consumption lamps - Private Areas</td>
</tr>
<tr>
<td></td>
<td>Saving devices - Common Areas</td>
</tr>
<tr>
<td></td>
<td>Individualized Measurement - Gas</td>
</tr>
<tr>
<td>Material Resources Conservation</td>
<td>Quality Materials and Components</td>
</tr>
<tr>
<td></td>
<td>Forms and Reusable Anchors</td>
</tr>
<tr>
<td></td>
<td>Construction and Demolition Waste Management (RCD)</td>
</tr>
<tr>
<td>Water Management</td>
<td>Individualized Measurement - Water</td>
</tr>
<tr>
<td></td>
<td>Saving Devices – Discharge System</td>
</tr>
<tr>
<td></td>
<td>Permeable areas</td>
</tr>
<tr>
<td>Social Practices</td>
<td>Education Management RCD</td>
</tr>
<tr>
<td></td>
<td>Environmental Education Employees</td>
</tr>
<tr>
<td></td>
<td>Guidance for Residents</td>
</tr>
</tbody>
</table>


It is observed by table 2 that the basic requirements for this certificate takes into account urban quality factors that seek to provide quality of life for residents by requiring the existence of infrastructure, trade and services around the venture. In addition, this category is essential that the project keep a distance within at least 2.5 km from noise sources and excessive odors and constant (JOHN; PRADO, 2010).

In the "design and comfort" this certificate prioritizes thermal comfort in three of the five items through projects strategies such as the implementation of the building considering the orientation of the sun and prevailing winds, the regulation of moisture through the trees with the use of landscape elements and, finally, better control of sunlight and ventilation through the external seals of the enterprise. Concern about physical activity related entertainment of residents and the sorting of waste in selective collection was not ruled out in this category (JOHN; PRADO, 2010).

Giving priority to the conservation of material resources can reduce waste rate during construction. To
obtain the certificate is required to be avoided low quality materials in order to reduce the unnecessary waste of natural resources with subsequent repairs and improve performance in the construction of the building. The use of molds and reusable anchors, as well as management of construction and demolition waste according to CONAMA resolution n. 307 e n. 348 (JOHN;PRADO, 2010 apud MMA, 2002 e 2004) may impound the waste of resources during the construction of the project. As in any environmental certification practices for water management and energy efficiency are mandatory. In the case of “Blue House” individual measurements of water and gas, energy-saving lamps and saving devices in common areas such as presence and discharge sensors with dual drive 3l and 6l are indispensable for the minimum requirements to obtain a certificate. In addition to concern for the environment, there was a concern with social factors awareness of residents and employees making mandatory investment in environmental education (JOHN; PRADO, 2010).

In 2011, The company “Rögga Joinville / SC” won the first gold certified Casa Azul in the construction of residential Bonelli. In the project, care has been taken with the location of sites for storage and collection of recyclable materials, ventilation and natural lighting, green areas and leisure, saving system of water and energy, among others. In addition to practical criteria, the project also met criteria for social practice category where all employees were instructed on sustainability (FASTOSKI; GONZÁLEZ; KERN, 2015).

**Image 1** Residential Bonelli, awarded gold certified Casa Azul.

![Source RÖGGA 2011](image)

Obtaining the certificate Casa Azul is voluntary and provides benefits such as reducing urban impacts of buildings, better user quality of life, overall reduction of environmental impact in life and lower maintenance costs and infrastructure.

### 4 METODOLOGY

Among a wide range of certified Casa Azul was chosen for a case study between a conventional work and sustainable work. These works are part of a unifamily project of approximately 50 m² which includes a simple house with two bedrooms, bathroom, great room, kitchen and service area as in Image 2:
From the project, will be made one budget work using as a base to research the SINAPI (National System for Research and Indexes of Construction) and inputs with market values for the case of conventional work and sustainable work, done that, there will be the comparison between the results and will be an analysis to assess the time of return and cost benefit of having a sustainable project by obtaining the Casa Azul Certification.

Sustainable work meet the criteria necessary to achieve the gold level Casa Azul Certification. In addition to the mandatory requirements follows in Table 3 the chosen optional requirements:

**Table 3** Optional criteria divided by categories.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Optional criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and Comfort</td>
<td>Workaround Transport</td>
</tr>
<tr>
<td></td>
<td>Natural Lighting of Common Areas</td>
</tr>
<tr>
<td></td>
<td>Bathrooms Natural Ventilation</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>Solar Heating System</td>
</tr>
<tr>
<td></td>
<td>Alternative energy sources</td>
</tr>
<tr>
<td>Material Resources Conservation</td>
<td>Industrialized components or Precast</td>
</tr>
<tr>
<td></td>
<td>Blast Furnace Cement (CPIII) and Pozzolanic (CP IV)</td>
</tr>
<tr>
<td></td>
<td>Facade of Serviceability</td>
</tr>
<tr>
<td>Water Management</td>
<td>Economizers devices - Aerators</td>
</tr>
<tr>
<td></td>
<td>Economizers devices - Registration Flow Regulator</td>
</tr>
<tr>
<td></td>
<td>Storm water utilization</td>
</tr>
<tr>
<td></td>
<td>Storm water retention</td>
</tr>
</tbody>
</table>

Thus, this case study is intended to be a demonstration to large ecological projects and through companies and investors can judge how far worth the sustainable investment of a unifamily residential project.

5 RESULTS ANALYSIS

To make the budget work of conventional and sustainable projects obtained, as expected, divergence in their final values. As we can see in Table 4:

<table>
<thead>
<tr>
<th>Activities</th>
<th>Conventional Budget</th>
<th>Sustainable Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry</td>
<td>R$ 8,391,65</td>
<td>R$ 8,391,65</td>
</tr>
<tr>
<td>Slab</td>
<td>R$ 5,328,35</td>
<td>R$ 5,203,40</td>
</tr>
<tr>
<td>Casings</td>
<td>R$ 6,308,20</td>
<td>R$ 6,352,20</td>
</tr>
<tr>
<td>Internal Plastering</td>
<td>R$ 1,070,61</td>
<td>R$ 1,070,61</td>
</tr>
<tr>
<td>Plaster of Paris</td>
<td>R$ 1,492,18</td>
<td>R$ 1,492,18</td>
</tr>
<tr>
<td>Floor, Tile and Stone</td>
<td>R$ 3,329,07</td>
<td>R$ 3,329,07</td>
</tr>
<tr>
<td>Plaster Lining</td>
<td>R$ 102,54</td>
<td>R$ 190,72</td>
</tr>
<tr>
<td>Superior Reservoir</td>
<td>R$ 1,649,54</td>
<td>R$ 1,497,83</td>
</tr>
<tr>
<td>External Plastering</td>
<td>R$ 3,179,64</td>
<td>R$ 3,179,64</td>
</tr>
<tr>
<td>Sidewalk</td>
<td>R$ 687,18</td>
<td>R$ 4,893,88</td>
</tr>
<tr>
<td>Internal Painting</td>
<td>R$ 3,144,94</td>
<td>R$ 3,144,94</td>
</tr>
<tr>
<td>Exterior Paint</td>
<td>R$ 1,935,24</td>
<td>R$ 1,935,24</td>
</tr>
<tr>
<td>Cleaning</td>
<td>R$ 1,697,58</td>
<td>R$ 1,802,85</td>
</tr>
<tr>
<td>Roof</td>
<td>R$ 6,047,00</td>
<td>R$ 6,047,00</td>
</tr>
<tr>
<td>Internal Gas</td>
<td>R$ 0,00</td>
<td>R$ 777,12</td>
</tr>
<tr>
<td>Electrical Installations</td>
<td>R$ 5,437,84</td>
<td>R$ 33,571,75</td>
</tr>
<tr>
<td>Telephonic Installations</td>
<td>R$ 226,68</td>
<td>R$ 226,68</td>
</tr>
<tr>
<td>Hidrossanitários Installations</td>
<td>R$ 4,327,81</td>
<td>R$ 4,528,41</td>
</tr>
<tr>
<td>Preliminary Services</td>
<td>R$ 24,017,34</td>
<td>R$ 24,017,34</td>
</tr>
<tr>
<td>Landscaping</td>
<td>R$ 0,00</td>
<td>R$ 1,067,92</td>
</tr>
<tr>
<td>Drainage Network</td>
<td>R$ 0,00</td>
<td>R$ 5,679,83</td>
</tr>
<tr>
<td>Social practices</td>
<td>R$ 0,00</td>
<td>R$ 5,000,00</td>
</tr>
<tr>
<td>Total</td>
<td>R$ 78,373,48</td>
<td>R$ 123,401,12</td>
</tr>
</tbody>
</table>

Source: Preparation of authors

The budget was based on data SINAPI June 2016 inputs that did not contain this search system were obtained from market research in the region. Should note that the step Foundation was not budgeted since there would be no change between projects, and therefore not impact the final analysis of the results.

Table 4 contains all the activities that were budgeted in projects, inputs, unit compositions and memorials calculation were concealed for the purpose of objective presentation of results. Before that, it is
important to remember that the project implementation have some criteria were already surrounding the chosen site for the project as a public water supply, electricity, public lighting and sewage treatment network or active during the construction process as the case of waste management.

From this, we observe that there are some activities in which the values of the work models do not change because they were not considered any input or unit composition sustainable practices, while others there were small or significant changes.

In items slab and plaster lining the divergence between the results occurred to meet the optional criteria cited in Table 3 (industrial components or pre-made), which consist of the installation of internal partitions of drywall and the choice of pre-slabs manufactured in sustainable work project. However, in the conventional construction, we opted for concrete slabs in the work. Moreover, this activity has been met the criterion of reusable forms and anchors for both cases.

In Casings activity there were not very considerable differences, but necessary to meet the requirements in the category of design and comfort, we increase the spans of windows in the bathroom and common areas in order to improve the thermal performance of the building. While in electrical installations there were crucial differences between the results with the installation of solar energy system satisfying the energy efficiency category.

In Table 4, we realize that there are some activities in which it was considered only sustainable work that is the case of internal gas, drainage network, landscaping and social practices. These activities have been added to meet the required and optional requirements easily found in Tables 2 and 3, such as individual metering of gas, including recreational areas and post-work waste management with separate collection bins. Also, no less important, funds were included for project design in order to meet the category of social practices such as environmental education and waste management. The image 5 gives us the visual sense, in financial terms, of the items there were changes in their budgeted amounts.

**Image 5** Visual comparison between activities with different budget amounts.
It is clear that the biggest difference of investment happens in electrical installations, but as more detailed forward is where we get the greatest share of economy. This high initial investment is due to the exorbitant equipment values developed with advanced technologies.

5.1 WATER MANAGEMENT

This certificate water management is a mandatory requirement that contains items that bring little or no financial return, not being attractive to entrepreneurs and investors, such as the system of permeable areas. However, optional and mandatory requirements can generate significant financial returns that is the case of dual drive exhaust system. This system has an average savings of 35% water discharges compared to the simple drive, this equates to a savings of 2000 liters/month (ASTRA, 2015). Another system that can be attractive and widely used is the drainage network system.

Image 3 Dual drive exhaust system

The drainage network system consists of rainwater harvesting and reuse for less noble use, such as: yard cleaning, car washing, watering plants, etc. From this it has been designed a drainage network system based on the monthly rainfall in the city of Rio de Janeiro / RJ which is equivalent to 106.5 mm (CLIMATE-DATA.ORG, 2015) was granted an average monthly reuse capacity of 5169 liters.

According to CEDAE (2016), a provider of state of the water supply of Rio de Janeiro, the unit rate for the category that includes our enterprise is R$ 3.31/m³ of water. Thus, we can conclude that in water management will have an approximate average monthly savings of 7169 liters, generating savings of R$ 23.73/month on your water bill. According to the investment seen in Table 4 (Drainage Network), about R$ 6,000 in water management, would reach the return on investment in a period of 21 years, with negligible
costs for maintenance.

Finally, we consider that beyond the financial view is important to have appreciation of the ecological well as the scarcity of water is a frequent subject in the news worldwide.

5.2 ENERGY EFFICIENCY

Just as water management, energy efficiency also has requirements that have little financial return and other items, on the other hand, they may make it worth the high initial investment in this activity. Among the optional and mandatory requirements are the solar heating system, energy-saving lamps and alternative energy sources. The total investment for this purpose inserted in Table 4 (Electrical Installations) is approximately R$ 28,000, which is a significant investment considering the type of project.

The energy generated from a solar photovoltaic system device of 2.0 kWp (used in our project) is close to 70,000 kWh in 25 years. In addition to investment, we should consider this analysis to the cost of maintaining this system that revolves around R$ 6,000.00. Thus, the average monthly price of energy during this period is R $ 0.49/kWh.

According to AMPLA (2016), electricity supplier in the state of Rio de Janeiro, the unit rate for the category of our enterprise is around R$ 0.80/kWh. According to Table 5, we can see the economy for as long as:

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Comparative monthly cost of solar energy and conventional energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Tariff</td>
<td>Solar Energy</td>
</tr>
<tr>
<td>Average Consumption</td>
<td>R$ 107.80/month</td>
</tr>
</tbody>
</table>

Source Preparation of authors

Based on this, it is clear to realize savings of R $ 68.20 in monthly energy bill this item. Moreover, through a boiler this system can heat the water in the shower. The solar heating system can generate savings of R $ 6.00 in an 8 minute shower (DIARIO OFFICIAL SAO PAULO cited Poli / USP, 2009) as specified in Table 6:

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Comparative monthly cost solar heater and electric shower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar heater</td>
<td>Electric shower</td>
</tr>
<tr>
<td>Cost per bath</td>
<td>R$ 0.04</td>
</tr>
<tr>
<td>Monthly cost</td>
<td>R$ 4.80</td>
</tr>
</tbody>
</table>

Source DIARIO OFICIAL DE SÃO PAULO 2009

Analyzing, we have the overall result of the solar energy device generates savings of R $ 74.20 per month. To obtain the return of the initial investment are needed 31 years. In addition to the financial view is valid attention to reducing the environmental impact of power generation, as solar energy, used in our
project as the largest reducing environmental impact, it is a clean energy, and we are favored by the high incidence of UV rays on account of being a tropical country.

6 CONCLUSION

From the analysis of the results we observed that the financial factor is still a major barrier to the construction of sustainable buildings since the time of return on investment is high, about 38 years. Therefore, environmental certificates can be seen as the kickoff of this building model as it is still necessary to further investment by government agencies to strengthen the idea further.

The strategy of environmental seals is functional because it keeps alive the idea of preserving the environment, but it requires a lot of entrepreneurs making it difficult to obtain certificates, not meaning thereby that we should stop taking ecological practical measures in order to reduce the great impact caused by the construction industry.

This study aimed to reach the Casa Azul certification, maximum level of this certification. As seen, had an unattractive result from a financial point of view, this form can be interesting to analyze the cost of less stringent categories stamp.

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Construction Cranes Parametric Cost Estimating

Glauco Bezerra da Silva, MSc, José Renato Góes de Paiva, Adalberto Ermida Franco, CRK, MBA, PMP

PETROBRAS Petróleo Brasileiro S.A.

ABSTRACT

Nowadays, there are several methodologies to estimate construction equipment costs, largely developed by manufacturers. These provided an adequate evaluation to determine economically between to rent equipment or to utilize own equipment.

This paper has as aim to present new approach of the estimating methodology to calculate owning costs and operating costs of large cranes and other load hoist equipment utilized in construction and assembly of industrial facilities projects in compliance with Brazilian legislation.

This methodology has been based in international parameters to calculate operational costs such as maintenance costs to achieve the lowest possible cost per hour to ensure the top machine performance and efficiency. For such, it has been necessary to define a selection of specimens for this study, setting a price quotation system. Through researched information, and the parameters set, it was observed the relevance of the results associated with the mechanical availability and operational efficiency of each type of cranes.

In despite to owning costs of cranes, the crane depreciation method utilized, is based on various factors: the long lifetime, the market conditions, brand reputation and general conditions of intended use.

So, the results of the costs per hour were gone converted to costs per month. These final results were gone compared with those available in the rental market, excepting mark-up.

Conclusions: It can be noted that the method brought results that maximize efficiency through realistic costs practiced by both the rental market and the construction companies and prove be fully applicable in public budgets of the government investments program.

The present study can be extended to others equipment, such as welding machines, test and measure-
ment instruments. It is necessary to evaluate its applicability, defining the mandatory parameters that must be considered.

**Keywords:** estimating; operating costs; cranes; construction

1 INTRODUCTION

Nowadays, there are several methodologies to estimate construction equipment costs, largely developed by manufacturers. These provided an adequate evaluation to determine economically between to rent equipment or to utilize own equipment.

The core of these suggested methods is to be able to estimate with a reasonable degree of accuracy what a machine will cost per hour. The result can be called as cost of utilization and is influenced by the following factors:

- purchase cost (including attachments)
- ownership period
- available operating time (hours)
- capital interest rate (%)
- maintenance factors (K)
- fuel consumption rates for flywheel horsepower hour (gal/fwhp-hr)

It is observed that is satisfactorily applicable to equipment such as excavators, bulldozers, wheel loaders, and in general transport vehicles. It is also widely utilized for cost estimates of agricultural equipment. However, there is no evidence or studies on the application of a deterministic method for calculating of operating costs for cranes and other load-lifting equipment. In addition, equipments of electro mechanical assembly also do not have references about the cost calculation due to its operation.

It is generally-accepted in cost engineering practices that such machines always be available at jobsites over the whole period of implementation, i.e., cranes.

Cranes, from the perspective of the owner, are an important initial investment, but, they have been a very profitable product, because of their long life and their fast return. However, there are difficulties for banks and insurance companies in measuring the return of investment.

In general, the cost of equipment is one of the largest categories of outlay for the contractor. It is a cost subject to many variables and uncertainties. Two questions must be answered carefully for equipment owners to succeed on the cost of their machines:

1. How much does it cost to operate the crane in a project?

2. What are the optimal economic life and the way to save a crane?
The process of selecting a specific type of crane for use in the construction of a project requires knowledge of the cost associated with machine operation in the site. In selecting the appropriate machine, the contractor seeks to obtain the lowest possible cost of unit production. To bidding projects and cost estimates, it is essential to know what the cost of owning and operating costs expressed in dollars per hour.

This paper aims to present the new approach to the methodology of estimating owning and operating costs of large cranes and loading equipment utilized in construction and erection of industrial plants projects in accordance to Brazilian legislation.

Also seeks to define the criteria for the correct application of the method in cost estimates The methodology presented here is guided by a systematic data collection, use of economic engineering techniques and parameters for load lifting operations with cranes.

2 DETERMINISTIC MODEL

The determination of cost per hour involves a variety of incident factors and seeks to approach the appropriate real costs under any parameters. In short, it aims to identify and estimate partial costs through available data of the machines and the level of knowledge of costs engineer.

For the development of the methodology, initially, it will be defined which items should be considered for the deterministic calculation of utilization cost per hour of a configuration of a crane that is used in load-lifting services in construction and assembly works.

The assumption is to stick to only the part relating to costs with owning and operation. Not covered in this study, costs for the mobilization and erection of the equipment.

In compliance with local laws, the purpose of the method is to get values of cost per hour for uptimes and downtimes.

Therefore the prices of equipment can be understood in economic terms on fixed and variable costs of equipment in operation measured by cost of hours worked and unproductive time.

2.1 Conceptual Basis

2.1.1 Uptime and Downtime Definitions

The time of use of equipment considers concepts of mechanical availability and operational efficiency which provides an evaluation the construction planning in terms of the uptime and downtime.

The mechanical availability (MA) is defined as the percentage of scheduled service time that the machine is mechanically able to perform productive work, not considering hence the time that the machine is in repair or maintenance. It is a quantity that indicates how long a machine is in perfect condition in relation to the total usable time. It can be expressed by Equation (1).
where:
MA = mechanical availability ratio (%)
AMT = available mechanically time, in hours
UPT = useful potentially time, in hours
MP = maintenance period, in hours.

Operational efficiency (OE) is defined as the percentage of time worked effectively in relation to the scheduled time of service. It can be understood as the relationship points as the time available equipment works effectively. Times spent with positioning equipment, instructions, and reduce offsets, for example, the time in which the machine works. It can be expressed by Equation (2).

\[
OE = \frac{WET}{AMT} \times 100 = \frac{UP}{(UP + C)} \times 100
\]  

where:
OE = operational efficiency ratio (%)
WET = worked effectually time, in hours
AMT = available mechanically time, in hours
UP = uptime, in hours
C = constraint during the operation, in hours

Therefore, the time of utilization can be defined by the relationship between uptimes and downtimes through the utilization factor (UF) which is the product of mechanical availability with operational efficiency, as shown in Equation (3).

\[
\%UF = MA \times OE
\]  

Figure (1) expresses the relationship between uptime and downtime time of utilization of equipment.
2.1.2 Cost of utilization

The costs occurring in the utilization of equipment can be classified into three groups:
- ownership costs
- operating costs
- maintenance costs.

The group ownership costs can also be called fixed costs, and this group makes up the parcels related depreciation and investment interest. For equipment mounted on truck, in compliance with Brazilian legislation, parcel related to insurance and vehicle taxes are added to this group.

Other groups represent variable costs according to the operating conditions defined in the use of the equipment. They consist of the parcel cost related with consumable materials in the operation, such as consumption of fuel, lubricants, grease, filters, operating labor costs, undercarriage costs and costs of mechanical maintenance.

Therefore the general expression of the cost of utilization of equipment is given in Equation (4).

\[
C = \frac{P - S}{Na} + \frac{i}{a} \left[ \frac{(P - S)N + 1}{2N} + S \right] + (C_{mat} + C_{labor}) + \frac{kP}{Na} \tag{4}
\]

where:
- \( P \) = purchase cost
- \( S \) = salvage value or residual value
- \( N \) = useful life, in years
- \( a \) = available hours per year
- \( i \) = annual interest rate
- \( C_{mat} \) = consumable materials cost (included fuel)
- \( C_{labor} \) = operating labor cost
- \( k \) = factor of repair mechanics

During the downtime, the machine is at the disposal of the operation, however, is not being used. To calculate the actual cost in this particular period, disregard the incidence of the cost of consumables and the costs of mechanical repairs. Thus, the expression of the cost of utilization is given by Equation (5) and is called downtime cost.

\[
C_{a} = \frac{P - S}{Na} + \frac{i}{a} \left[ \frac{(P - S)N + 1}{2N} + S \right] + C_{labor} \tag{5}
\]
2.2 Referential Basis

For scope of this paper, it was considered types and cranes settings most commonly used in onshore industrial construction projects. It was also defined as a premise, evaluate models of cranes still in manufacturing, to minimize the impact of obsolescence due to technological upgrading. It was also considered manufacturers with global operations in the crane market.

The families or groups of cranes listed in Table 1 below, was based on the Sobratema Equipment Guide 2014-2016, since the equipment which is manufacturers operate in Brazil.

<table>
<thead>
<tr>
<th>Crane Type</th>
<th>Mounted</th>
<th>Boom</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>All terrain (AT)</td>
<td>All wheel truck</td>
<td>telescopic</td>
<td></td>
</tr>
<tr>
<td>Truck-crane (TC)</td>
<td>truck</td>
<td>telescopic</td>
<td></td>
</tr>
<tr>
<td>Rough terrain (RT)</td>
<td>undercarriage</td>
<td>telescopic</td>
<td></td>
</tr>
<tr>
<td>Crawler crane</td>
<td>undercarriage</td>
<td>telescopic</td>
<td></td>
</tr>
<tr>
<td>Crawler crane</td>
<td>undercarriage</td>
<td>truss</td>
<td></td>
</tr>
<tr>
<td>Tower crane</td>
<td>concrete slab</td>
<td>variable</td>
<td></td>
</tr>
</tbody>
</table>

3 USAGE CRITERIA

The process of selecting a particular type of machine for use in the preparation of a project requires knowledge of the associated costs.

3.1 Crane Capacity Index (CCI)

One of the criteria used for selecting cranes for this study was the application of Crane Capacity Index (CCI), developed by European Association of Abnormal Road Transport and Mobile Cranes (ESTA), to guide the choice of a crane for investors, rental companies, and owners. The CCI is in Te.m² and basically is calculated as follows:

- radius
- lifting height
- capacity.

The base formula for the CCI is presented in Equation 6 as follows.
\[ CCI = \frac{\text{average}(R \cdot \max(LH \times Cap))}{100} \]  

where:
- \( R \) = radius, in meters (m)
- \( LH \) = lifting height, in meters (m)
- \( \text{Cap} \) = capacity, in metric tons (Te).

To clarify calculations, this base dimensions, for example, is presented in Figure (2). A is the distance between crane center and pivot point main boom, B is the height of crane pivot point and C is the sheaves distance.

Soon for each crane reference base was calculated their respective CCI. The selection criterion was to select the crane with the largest CCI from the cranes of the same type and nominal capacity. The overview results are presented in Table 3.

**Figure 2** Base dimensions for CCI calculation.
4 REQUEST FOR QUOTATION

The price quotation process of acquisition was carried out with the selected manufacturers according to the systematic presented below.

4.1 Systematic

The currency chosen was the dollar and the acquisition value should include all taxes and additional charges with CIF shipping to the city of Rio de Janeiro, Brazil. The acquisition values obtained refer the purchase cash payment.

Two methods are chosen for the calculation of the depreciation time: the linear function method and the method of average annual investment.

The machine depreciates every year to a constant value for the life. The choice of this method due to its simplicity and comply with tax Brazilian rules.

The second approach to the calculation of the portion of the depreciation cost uses the average value of the machine multiplied by the cost of capital rate will make the monetary portion of the capital interest plus installment of straight-line depreciation results in the cost of ownership of equipment.

4.2 Definition of Useful Life and Residual Value

In practice it is quite difficult to safely establish the time when the useful life has been reached. The correct and realistic determination of the number of probable years of life is dependent on data provided by the settlement. Some manufacturers have developed data tracking systems for the operation, mechanical repairs and technological modifications.
Anyway, it is known that during the life of the equipment maintenance costs grow over time due to natural wear.

The residual value of a crane relies on various factors:

- brand reputation
- model size
- model type (e.g. luffing, horizontal jib, self-erecting)
- year of manufacturing
- level of technology (kind of drives, control system, safety features, other options)
- general conditions of intended use.

The chart below in Figure (3) shows the residual values of tower cranes in comparison with their costs amortization.

To determine the useful life and residual value of each crane model, statistical programs were used to using multiple linear regressions. The variables were chosen so that they are significant in the construction of values of each type of crane.

5 CONCLUSION

It can also be noted that the method brought results that maximize efficiency through realistic costs charged by both the rental market and the construction companies and should be fully applicable in public budgets aimed at economy and the performance of the buildings of government investments.

The present study can be extended to other equipment's, such as welding machines, test and measurement instruments. It is necessary to evaluate its applicability defining the mandatory parameters that must be considered.
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Using EVM – Earned value Management as a tool for monitoring the trend of time & cost in projects

Ricardo de Lima Delarue

ABSTRACT

1.1.1 It is worldwide known how challenge it is to guarantee the contractual completion date of all kinds of Projects. Variations happens, changing the scope of the contract and even its workability, lack of efficiency of the direct resources, clashes with other Contractors working at site simultaneously and many other unpredictable situations.

1.1.2 A huge number of companies do have their own Planning Department, which is able to identify the scope of the works, develop the WBS – Working Breakdown Structure and identify the resources and productivity rates for making the EPC Program and its progress update, accordingly.

1.1.3 The author of this paper does not consider this procedure to be enough for monitoring the trend of time & cost of the project. This is because many companies use the updated program as a tool just to report what happened at site, but not what is the trend of the project due to its status.

1.1.4 The goal of this paper is to demonstrate that on using EVM – Earned Value Management, summarized by the direct working hours, it is possible to forecast the completion date of each activity ongoing and therefore, also the trend of the completion date of the contract, just based on the evaluation of the efficiency of the direct resources.

1.1.5 Additionally, this procedure is a very useful tool also for the evaluation of the trend of the cost of the contract, just because the actual productivity of the direct resources will be known, per activity of the WBS, allowing the update of all the unit prices and consequently the cost of the entire Contract.

2.0 INTRODUCTION

2.1.1 This job was made based on my site experience in Project Control Management, in different types of Contracts in Brasil, Kuwait, Dubai, Indonesia, Iran and Morocco.
2.1.2 After 17 years with recurrent success of using this methodology, I decided to present it on this Congress, but I had also to develop the process to transform the practice at site, in theory.

2.1.3 Firstly I found important to identify two basic questions that would allow the sponsors of the Contract to receive some enough and reliable information, as follows:

a) What the Project status is, in regards the contractual completion date?

b) What is the current Project cost situation and therefore its trend of profitability?

2.1.4 In order to answer these questions, my research started in 1999, on reading the best practices available in Project Management, targeting on how to implement them at site, transforming the theory in practice.

2.1.5 I was already an user of EVM (Earned Value Management) for Progress & Cost Control, but this methodology was not fully answering the 2 questions, since it was not providing any information in regards the trend of time & cost of the contract.

2.1.6 Curiously, still using EVM, I was able to answer all the questions simply changing the way to summarize the relative weights of the WBS (Working Breakdown Structure), from cost to direct hours. This is the methodology presented on this work.

3.0 BASIC CONCEPTS

3.1 Production x productivity

3.1.1 For a better understanding of the content of this document, there are some basic concepts to be informed. The first one is the difference between production and productivity.

3.1.2 Production is the quantity of some activity of the WBS executed in a certain amount of time, as an example:

The production of concrete during this month was 3,000 m³.

3.1.3 Productivity is the result of the division of the number of direct hours spent by the production that happened, as an example:

It was spent 24,000 direct hours for the execution of 3,000 m³ of concrete. This means that the productivity is:

Concrete Productivity: 24,000 h / 3,000 m³ = 8.00 h / m³.
3.2 Unit Price Composition

3.2.1 The UPC – Unit Price Composition is an instrument that allows the Contractor to understand not only the unit price of an activity, but also how the execution of the activity was defined to be made.

3.2.2 As an example, let’s consider that the activity is about laying of secondary cable trays, on which the progress measurement is in meter.

3.2.3 During the bid phase the Company “A” presented the following Unit Price Composition:

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit</th>
<th>Productivity rate</th>
<th>Unit Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable tray 50 mm</td>
<td>meter</td>
<td>1,05</td>
<td>US$ 8.00</td>
<td>US$ 8.40</td>
</tr>
<tr>
<td>Clamp for fixing the tray</td>
<td>unit</td>
<td>1</td>
<td>US$ 0.45</td>
<td>US$ 0.45</td>
</tr>
<tr>
<td>Man Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skilled Worker - Fitter</td>
<td>hour</td>
<td>0,15</td>
<td>US$ 15.00</td>
<td>US$ 2.25</td>
</tr>
<tr>
<td>Helper</td>
<td>hour</td>
<td>0,30</td>
<td>US$ 11.45</td>
<td>US$ 3.43</td>
</tr>
<tr>
<td>Equipments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>not aplicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unit Price</strong></td>
<td></td>
<td></td>
<td><strong>US$ 14.50</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Planned Productivity (h/m)</strong></td>
<td></td>
<td></td>
<td><strong>0.45</strong></td>
<td></td>
</tr>
</tbody>
</table>

3.2.4 This composition clearly indicates that the cable will be installed using a clamp. The picture below is an example of the result of installing a cable tray using a clamp:
3.2.5 The company “B” presented the following Unit Price Composition:

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit</th>
<th>Productivity rate</th>
<th>Unit Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable tray 50 mm</td>
<td>meter</td>
<td>1,05</td>
<td>US$ 8.00</td>
<td>US$ 8.40</td>
</tr>
<tr>
<td>Support for the tray in carbon steel</td>
<td>Kg</td>
<td>0.3</td>
<td>US$ 5.00</td>
<td>US$ 1.50</td>
</tr>
<tr>
<td><strong>Man Power</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skilled Worker - Fitter</td>
<td>hour</td>
<td>0.15</td>
<td>US$ 15.00</td>
<td>US$ 2.25</td>
</tr>
<tr>
<td>Helper</td>
<td>hour</td>
<td>0.30</td>
<td>US$ 11.45</td>
<td>US$ 3.43</td>
</tr>
<tr>
<td>Skilled Worker - Welder</td>
<td>hour</td>
<td>0.20</td>
<td>US$ 17.00</td>
<td>US$ 3.40</td>
</tr>
<tr>
<td><strong>Equipments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welding Machine</td>
<td>hour</td>
<td>0.20</td>
<td>US$ 1.14</td>
<td>US$ 0.23</td>
</tr>
<tr>
<td><strong>Unit Price</strong></td>
<td></td>
<td></td>
<td></td>
<td>US$ 19.21</td>
</tr>
<tr>
<td><strong>Planned Productivity (h/m)</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
</tbody>
</table>

3.2.6 The same activity (installation of secondary 50 mm cable trays) has a completely different price and productivity index.

3.2.7 The reason for that is that the company “B”, chose a different way to install the cable tray, using support made in carbon steel instead of clamps, like the previous company. The picture below is an example of how the company “B” intended to support the cable tray:

3.2.8 Based on this basic concept, the first target is to have the Unit Price Composition for each activity of the WBS – Working Breakdown Structure. Once this information is available, it will be possible not only to identify the total cost of the project, but also the planned direct hours for the entire scope of the works.

3.3 Relative weights summarized by the planned direct working hours

3.3.1 Once all the Unit Price Composition are available, the second target of this job is to
identify the relative weights of the WBS – Working Breakdown Structure of the contract, summarized by the planned direct working hours.

3.3.2 The example below presents how the relative weights are calculated. It is a contract with 15 activities, which are presenting several different control units:

<table>
<thead>
<tr>
<th>Activity #</th>
<th>Quantity (a)</th>
<th>Control Unit</th>
<th>Productivity rate - h/unit (b)</th>
<th>Total planned worked hours (c) = (a) x (b)</th>
<th>Relative weigh</th>
</tr>
</thead>
<tbody>
<tr>
<td>activity 1</td>
<td>1500</td>
<td>meter</td>
<td>0.70</td>
<td>1.050,00</td>
<td>0.11%</td>
</tr>
<tr>
<td>activity 2</td>
<td>100</td>
<td>unit</td>
<td>0.70</td>
<td>70,00</td>
<td>0.01%</td>
</tr>
<tr>
<td>activity 3</td>
<td>250</td>
<td>m³</td>
<td>12.00</td>
<td>3.000,00</td>
<td>0.30%</td>
</tr>
<tr>
<td>activity 4</td>
<td>500</td>
<td>gallon</td>
<td>0.70</td>
<td>350,00</td>
<td>0.04%</td>
</tr>
<tr>
<td>activity 5</td>
<td>10000</td>
<td>Ton</td>
<td>35.00</td>
<td>3500000,00</td>
<td>35.00%</td>
</tr>
<tr>
<td>activity 6</td>
<td>2000</td>
<td>m²</td>
<td>6.00</td>
<td>12.000,00</td>
<td>1.20%</td>
</tr>
<tr>
<td>activity 7</td>
<td>5000</td>
<td>meter</td>
<td>0.25</td>
<td>1.250,00</td>
<td>0.13%</td>
</tr>
<tr>
<td>activity 8</td>
<td>500</td>
<td>unit</td>
<td>9.00</td>
<td>4500,00</td>
<td>0.45%</td>
</tr>
<tr>
<td>activity 9</td>
<td>3000</td>
<td>m³</td>
<td>18.00</td>
<td>5400000,00</td>
<td>5.40%</td>
</tr>
<tr>
<td>activity 10</td>
<td>2000</td>
<td>liter</td>
<td>11.50</td>
<td>2300000,00</td>
<td>2.30%</td>
</tr>
<tr>
<td>activity 11</td>
<td>15000</td>
<td>Ton</td>
<td>33.00</td>
<td>4950000,00</td>
<td>49.50%</td>
</tr>
<tr>
<td>activity 12</td>
<td>2000</td>
<td>m²</td>
<td>4.39</td>
<td>87800,00</td>
<td>0.88%</td>
</tr>
<tr>
<td>activity 13</td>
<td>4000</td>
<td>meter</td>
<td>0.40</td>
<td>1600,00</td>
<td>0.16%</td>
</tr>
<tr>
<td>activity 14</td>
<td>800</td>
<td>unit</td>
<td>0.50</td>
<td>400,00</td>
<td>0.04%</td>
</tr>
<tr>
<td>activity 15</td>
<td>3000</td>
<td>m³</td>
<td>15.00</td>
<td>4500000,00</td>
<td>4.50%</td>
</tr>
</tbody>
</table>

3.3.3 This information combined with the contractual baseline schedule, it is possible to create the planned S Curve, summarized by the working hours, which is our next topic.

3.4 Planned S Curve, summarized by the planned direct working hours

3.4.1 The two information needed for the creation of the planned S Curve are the relative weights and the contractual baseline schedule. Following the example of the previous topic, let’s consider that the schedule below is the baseline.
3.4.2 The total of hours, activity by activity is distributed in accordance to its duration and after that, on a monthly basis, it is cumulated, accordingly.

3.4.3 Based on this cumulative result, it is possible to create the Planned S curve, obviously summarized by the working hours, which is presented in the picture below.
3.5 Progress & efficiency monitoring

3.5.1 The step forward is to start the monitoring of the production that is happening at site and the productivity of the direct work force, accordingly.

3.5.2 There are several ways of doing it. I use this methodology below in many different projects that I worked in my entire career. For using it, there are some basic considerations, as follows:

a) There will be a new function at site, which is the “Appropriator”, that will be responsible of tracking the production (or quantities executed) and productivity (or hours per quantity produced) of each group of 150 men, on a daily basis.

b) My experience states that every 15 men, needs to have on foreman managing their works.

c) It means that the Appropriator will be responsible to take the production & productivity of each group of 10 foreman. The picture below summarizes the situation.

![Diagram showing foreman and appropriator with direct manpower]

d) For doing do, obviously, the appropriator must work jointly with each foreman to collect every production / productivity on a daily basis.

3.5.3 The result of the work of the Appropriator, on a daily basis, will be as follows:

- Availability of all the quantities produced on a daily basis per each working team.
- Availability of each productivity of each working team on a daily basis.

3.5.4 This information is fundamental for identifying the trend of the completion date of the contract, but this is not all needed for this document. It is missing the cost control, which is in the next topic.
3.6 Cost Monitoring

3.6.1 The target is not to control the cost of the project, but control the unit price of each activity considered in the WBS – Working Breakdown Structure of the Contract.

3.6.2 For doing so, it is needed to, once more, present an example of an Unit Price Composition, as follows:

3.6.3 On this example, several items are to have a good periodical traceability in order to have the unit price of this activity properly updated. Basically the information needed are:

- Control of quantity of inputs (or material), on the example, cable tray and the support for the cable tray.
- Unit cost of each input
- Traceability of the productivity of the direct labor per category.
- Unit Cost of each labor category.
- Traceability of the productivity of each equipment used on this activity.
- Unit cost of each equipment

3.6.4 For a better understanding, let’s split the items in two: unit prices and the rest.

3.6.5 Each updated unit price comes from the invoices of the each input, which is quite easy to obtain.

3.6.6 The traceability of the productivity of the manpower and equipment is made on a daily basis by the appropriator.

3.6.7 It is missing just the traceability of the use of the inputs (material) for each activity.

3.6.8 The solution to get this information is also in the hands of the Appropriator. My experience informs that each appropriator can monitor not only the production and productivity the work of 150 men on a daily basis, but also the use of the inputs of the working team of one foreman per day.

3.6.9 The picture below clarifies this information, which on a daily basis; the Appropriator can track the production and productivity of 150 men and can have the use of inputs for the activities ongoing of one specific foreman, per day.
3.6.10 Based on this procedure, it is correct to declare that an Appropriator will have conditions to update the unit price of a group of activities under execution by each team of a foreman on a daily basis.

3.6.11 It means that the Appropriator will be able to update 10 different unit prices every 10 days.

3.7 Using EVM for progress & productivity monitoring

3.7.1 This is the final basic concept for effectively starting all the trend evaluation, which is the main purpose of this work.

3.7.2 It is correct to inform that the formula that allows the Planned S Curve presented on the paragraph 3.4, is as follows:

\[
\text{PH (Planned hours)} = \sum \text{Planned Productivity} \times \text{Planned Quantities}
\]

3.7.3 Using the basic concepts of EVM – Earned Value Management, the second curve presents the following formula:

\[
\text{EH (Earned hours)} = \sum \text{Planned Productivity} \times \text{Actual Quantities}
\]

3.7.4 Just Using Algebra to compare the different parcels of the two formulas, it is easily possible to identify that the planned \(\times\) actual quantities are the parcel that will change the result of the formula.

3.7.5 It means that when we compare one formula to the other, we are comparing if we have executed (or produced) more or less quantities than the planned, on the same period, therefore we are identifying the progress of the works ongoing.

3.7.6 This information is not enough for evaluation the trend of the contract of time & cost. For doing so, we need to evaluate the productivity in accordance with the production that happened on the same period.
3.7.7 Still using EVM – Earned Value Management, the formula that will let us calculate the actual productivity that is happening at site is:

\[ \text{AH (Actual hours)} = \sum \text{Actual Productivity} \times \text{Actual Quantities} \]

3.7.8 Once again using Algebra, on comparing the EH (Earned Hours) with the AH (Actual Hours), there is one parcel that is common in both formulas, which is the actual quantities.

3.7.9 Based on this, it is correct to inform that when comparing EH X AH, the planned x actual productivity will identify the difference of the results from one formula to the other, in order words, we are comparing if the actual productivity is better or worse that the planned productivity.

3.7.10 The table below summarizes the two comparisons of the formulas.

<table>
<thead>
<tr>
<th>Planned Hours (PH)</th>
<th>Earned Hours (EH)</th>
<th>Actual Hours (AH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>2016</td>
<td>2017</td>
</tr>
<tr>
<td>04/jan</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>11/jan</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>18/jan</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>25/jan</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>01/feb</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>08/feb</td>
<td>35%</td>
<td>35%</td>
</tr>
<tr>
<td>15/feb</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>22/feb</td>
<td>87%</td>
<td>87%</td>
</tr>
<tr>
<td>29/feb</td>
<td>92%</td>
<td>92%</td>
</tr>
<tr>
<td>07/mar</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>14/mar</td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td>21/mar</td>
<td>97%</td>
<td>97%</td>
</tr>
<tr>
<td>18/mar</td>
<td>99%</td>
<td>99%</td>
</tr>
<tr>
<td>04/apr</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Graphically the result is presented as follows:
3.7.12 Let’s magnify the values of the graphic:

3.7.13 There is another basic concept to be informed: Efficiency, which is the result of the division of the Actual Hours (AH) by the Earned Hours (EH), presenting the 3 possibilities:

<table>
<thead>
<tr>
<th>Efficiency Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Hours (AH) / Earned Hours (EH) &gt; 1 = Bad efficiency</td>
</tr>
<tr>
<td>Actual Hours (AH) / Earned Hours (EH) = 1 = Efficiency as per planned</td>
</tr>
<tr>
<td>Actual Hours (AH) / Earned Hours (EH) &lt; 1 = Good efficiency</td>
</tr>
</tbody>
</table>

3.7.14 The Bad Efficiency means that the direct hours spent in one specific production were more than the planned for the same production.

3.7.15 The good efficiency is exactly the opposite, that the direct hours spent in one specific production were less than the planned for the same production.
3.7.16 Now let’s evaluate the information of three different weeks, as follows:

<table>
<thead>
<tr>
<th>Week #</th>
<th>PH x EH</th>
<th>AH / EH</th>
</tr>
</thead>
<tbody>
<tr>
<td>04 January</td>
<td>EH &gt; PH = ahead in progress</td>
<td>EH &gt; AH = good efficiency</td>
</tr>
<tr>
<td>18 January</td>
<td>EH &gt; PH = ahead in progress</td>
<td>EH &lt; AH = bad efficiency</td>
</tr>
<tr>
<td>01 February</td>
<td>EH &lt; PH = in delay</td>
<td>EH &lt;&lt; AH = terrible efficiency</td>
</tr>
</tbody>
</table>

3.7.17 Finally, all the basic information required for making the trend analysis of time & cost are available and is presented made in the next topic.

4.0 Trend Evaluation of the completion date of the contract

4.1.1. Firstly let’s evaluate what the information available is, based on the actions that were taken:

- Planned x Actual quantities executed of each activity of the WBS on a daily basis.
- Planned x Actual productivity of the direct resources on a daily basis.
- Updated schedule with the proper identification of the interdependences & floats.

4.1.2. For a better understanding of this part of this work, let’s keep the same example and estimate that we are on the end of the third month of the contract (our current cut off date).

4.1.3. The picture below provides this information visually:
4.1.4. Based on the content of the picture, it is easy to understand that the activities one and two are completed on time and the activities 9 and 11 are ongoing. Let’s make an evaluation of the production & productivity of these two activities:

4.1.5. Based on the content of this table, it is possible to calculate the efficiency of these two activities:

<table>
<thead>
<tr>
<th>Activities</th>
<th>Efficiency (AH / EH)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 9</td>
<td>(800 m³ x 15 h / m³) / (800 m³ x 18 h / m³) = 0.83</td>
<td>Good Efficiency</td>
</tr>
<tr>
<td>Activity 11</td>
<td>(3000 t x 40 h / t) / (3000 t x 33 h / t) = 1.21</td>
<td>Bad Efficiency</td>
</tr>
</tbody>
</table>

4.1.6. The Appropriator also informs us, on a daily basis, the number of working team per activity and therefore the number of working hours. Based on this information a second table presents some additional information.

4.1.7. On checking the planned completion date of these two activities, it is possible to identify that the activity 9 is postponing the planned completion date in one month, despite presenting a good efficiency, which indicates lack of direct manpower working at site.

4.1.8. The activity 11 is forecasting its completion date on time, but it is presenting a bad efficiency, because it is spending more direct hours than the planned.

4.1.9. Based on the trend of the completion date of the two activities ongoing at that moment, it is possible to forecast the trend of the completion date of the entire contract, as follows:
4.1.10. There are several solutions that can be made to mitigate this current trend, starting with the logistic of supply material to the work front, evaluation of the management capacity of the supervisors (or foreman) and taking into account that the efficiency is good on this activity, might be just a matter of hiring more direct resources for that specific work.

4.1.11. It is important to declare that this is just a trend, like an instant picture of the project situation. Many other events might happen that can impact the completion date of the contract in a good or bad way.

5.0 Trend evaluation of the final cost of the contract

5.1.1. Based on the current trend of completion date, it is possible to forecast the trend of the final cost of the contract.

5.1.2. For doing so, it is needed to have the following information:

- The update value of each Unit Price Composition, which means that we need to have the updated productivity rates, the updated hourly rate for the manpower, equipment’s, material and the material (or inputs) consumption per composition.

- The spreadsheet presenting the monthly overhead cost of the contract.

- The update bill of quantities.

- Change orders approved and list of variations of the contract.
5.1.3. The status of the availability of each information can be summarized on the table below:

<table>
<thead>
<tr>
<th>Information</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Available on a daily basis (appropriator)</td>
</tr>
<tr>
<td>Productivity rate</td>
<td>Available on a daily basis (appropriator)</td>
</tr>
<tr>
<td>Unit prices of materials / equipment</td>
<td>Available on the invoices</td>
</tr>
<tr>
<td>Hourly rate of the manpower</td>
<td>Available on the payment slip</td>
</tr>
<tr>
<td>Update Bill of quantities</td>
<td>Obtained from the AFC (approved for construction) drawings.</td>
</tr>
<tr>
<td>Overhead cost</td>
<td>Obtained from the Administration Area</td>
</tr>
</tbody>
</table>

5.1.4. The approved change orders & variations of the contract are additional costs that changes should be treated separately by the commercial & technical areas of the company, bearing in mind that the contract variations might compromise completely the planned margin of the contract.

5.1.5. The table below presents how to update the costs of the “Activity 9” of the example presented previously.

5.1.6. Let’s firstly name the activity as “Concrete: preparation and pouring”. The composition considered in the budget is presented in the table below:
5.1.7. The composition is informing the planned productivity of 18 h / m³ and also that the planned unit price for this activity is US$ 442.56 / m³.

5.1.8. The step forward will be to update all the information of the composition in accordance to the current productivity rate, material consumptions and unit prices, which is presented in the picture below, as follows:

![Activity: Concrete (preparation & pouring) (updated composition)](image)

5.1.9. On this example, it is easy to identify that the difference of the unit price that was mainly guided by the good efficiency that is happening at site from 18 h / m³ to 15 h / m³.

5.1.10. This good productivity was the main reason of unit price reduction from US$ 442.56 / m³ to US$ 406.00 / m³.

5.1.11. Taking into account that the balance of the works for this activity is 2200 m³ (see 4.1.4), the trend of price reduction only for this activity is:

![Activity: Concrete (preparation & pouring) - updated budget for this activity](image)

5.1.12. The same exercise is to be made for all the activities on going and, additionally, the unit price of the inputs of each composition is to be updated so that based on the balance of the works to be done it is possible to inform the trend of the final direct cost of the project.

5.1.13. In regards the overhead cost, the situation is the same, on which, it is possible to evaluate what the monthly cost is and forecast what the final cost of the contract will be.

5.1.14. Finally about the contract variations, such as change orders, Engineering Instructions and any event to be consider a variation, the impact of each variation in time and cost is also to be understood, following the process below:

- Identification of the variation
• Calculation of the cost of the variation, itself
• Identify which activities of the original scope of the works might be impacted due to each variation.
• Identify what this impact might be in time & cost.
• Make the calculation of the direct & indirect cost of each variation and consider it on the budget.

6.0 Conclusion

6.1.1. Once again, it is important to mention that the trend analysis is to be considered just a instant picture, of what might happen to the contract in regards time & cost, if the performance of the contractor is kept as it is.

6.1.2. This simple exercise is a tool that not only provides de trend, but also can explain where the problem is, which would let us to mitigate each problem as much as possible.

6.1.3. Based on my experience in many countries, I can declare that the cost of implementing this methodology is almost nothing, compared to the quality of information that the sponsors of the contract will have, on a weekly basis.

7.0 References

• Wilkens, T. T., April 1, 1999, Earned Value, Clear and Simple, p. 4, Los Angeles County Transit Authority.


• Ricardo Delarue & Peter Mello (2009), Efficiency, Delay Analysis & Forensic Schedule Analysis, 189 pages, Clube de Autores.


7.0  The Author

Ricardo de Lima Delarue, Brasilian Civil Engineer, over 34 years of experience on Project Management, acting in Projects in Brasil, Scotland, England, Spain, Peru, Kuwait, Dubai, Morocco, Indonesia, Iran, Chile, China and Switzerland, acting from Expert Witness in arbitrations to Project Control Manager.

In all these countries Ricardo worked in many different types of Projects, ranging from oil & gas, rail, energy (including nuclear), airports, military (radar and telecommunication stations), commercial and residential buildings, hotels, restoration / refurbishment, structural recoveries, public buildings, Industrial buildings including chemical and pharmaceutical, company headquarters, museums, cultural centers, commercial premises including shopping centers and renovation projects.

On 2015 Ricardo was awarded by IBEC & ICEC as CRK – Certified Remarkable Knowledge.

Currently Ricardo is Country Manager in Brasil of Systech International, a British Consultant company expert in elaboration or protections of claims, disputes & arbitrations, nowadays with 29 offices all over the world.
Semantics in Total Cost Management

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ABSTRACT

The paper focuses on some words that, albeit having the same etymology, assume a different meaning from one language to another: reference is made to English and Italian, together with some other Latin languages. Notwithstanding the fact that we are normally, in any business relationship, speak and write in English, in a lot of cases we are doing so with the mental filter of our mother tongue, namely we are using the English word with the meaning the same word has in our own language, and this can be cause of misunderstandings and confusion.

Majority of the words taken into consideration are related to our profession such as “project”, “controls”, “management”, “engineer”, “design” and so on.

Keywords: semantics, cost, management, engineering, project, controls, profession.

1 Foreword

There are different definitions of the word “semantics”. In this paper, we accept the definition found in Merriam Webster¹: “the study of meanings: the historical and psychological study and the classification of changes in the signification of words or forms viewed as factors in linguistic development” with the addition of “the study of different meaning that words, equal on etymological point of view and lexically corresponding, have in different languages”.

The earth of the matter is that words, that are lexically corresponding, not necessarily are semantically equivalent: they can have different meaning either in different languages or in the same language, in different time or in different social or cultural society. The relationship between a term and its meaning is not stable, neither through time nor through space, discipline and other contexts.

In fact, the relationship between a term and its meaning is changeable and unstable over time, as well as moving from one discipline to another: in other words, the same term used in different historical periods can have considerably different meanings and even among contemporaries, the same word can take on meanings or shades of meaning quite different depending on the subject or scientific discipline in which the term is used and the ideological structure of the user.

A synthetic definition could be “the branch of linguistics that studies the change of the meaning of the
words through time and space.

This is why the philosophes as well as the theologians of the Middle Ages put, at the beginning of their text, the explications of the meaning of the main terms they were to use. We do the same when we put the glossary among the first articles of a contract, a standard, a specification.

Furthermore, as far as we are concerned, in several cases there is a confusion between the word used for defining a “profession” and the word used to describe the related discipline or disciplines, namely the body of knowledge as well as of competences that are needed for the profession itself. This becomes more complicated where the profession is subject to standard or regulations, as well as in case the use of some titles is protected by the law, that is quite normal in Civil Law countries. For a better understanding of the meaning of a word, in all aspects, we must start from its origin, either lexically and etymologically, or taking into consideration the original meaning in the language where the word is born.

The main reference of this paper is to English as well as to Italian words, however some reference shall be made to other languages and Latin, Greek as well as other etymologies shall be mentioned. The paper is only limited to the analysis of some words commonly used in Total Cost Management as well as in other branch of the whole “project profession”.

It is worthy to make some considerations about the different translation of some words related to our profession in several languages:

<table>
<thead>
<tr>
<th>English</th>
<th>Italian</th>
<th>Spanish (castilian)</th>
<th>French</th>
<th>German</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost Management</td>
<td>Ingegneria Economica</td>
<td>Ingeniería, Financiera y de Costos</td>
<td>Gestion des coûts</td>
<td>Kostenmanagement</td>
</tr>
<tr>
<td>Cost Engineering</td>
<td>Ingegneria dei Costi</td>
<td>Ingeniería de Costos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>Gestione di progetto</td>
<td>Ingeniería de Proyecto</td>
<td>Management (gestion) de projet</td>
<td>Projektsleitung</td>
</tr>
<tr>
<td>Project Controls</td>
<td>Controllo di progetto</td>
<td>Control de Proyecto</td>
<td>Maîtrise de projet</td>
<td>Projektsteuerung</td>
</tr>
<tr>
<td>Project monitoring</td>
<td>Monizione del progetto</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following must be noted:

1. *Ingegneria Economica* in Italian has a wider meaning than the English “Total Cost Management”.
2. The term “Cost Engineering” is normally translated in Italian as *Ingegneria dei Costi*, however this a term difficult to explain to Italians.
3. On the other side, Project Finance is normally translated in Italian as *Finanza di Progetto* or *Finanza*
Strutturata while the term Ingegneria Finanziaria seems to have a negative meaning, due to how the term has been used in television and other media.

4. Project controls in English has a wider meaning than controllo in Italian and contrôle in French, where it would be probably more suitable the word maîtrise.

5. In military terminology, both in English and Italian, “command” and “controls” have a different meaning.

6. The correct word monizione for “monitoring” is not common in Italian, while is used the word monitoraggio that is actually a loan of a Latin word through the English language.

Then the first challenge should then be to issue a multilingual glossary of the terms used in the project profession in the main languages (not limited to the European languages), starting from the work already performed by AFITEP in year 2000; further works on terminology have been done by private companies such as FIAT, Snamprogetti (belonging to ENI group), PM Forum, PMA Europe Ltd. and others. Those works could be used for reference, together with the glossaries (in English) of the AACE International, PMI and others.

The work done by AFITEP is quite complete in French, German, English, Spanish and Portuguese; it needs to be updated as well as to be completed with other languages, such as Italian, Arabic and Chinese.

Project management & controls: definitions

A definition of project management could be “application of knowledge, competences and methodology to the management of a complex project, in order to keep the project within the given limits (scope, time, resources or costs)”.

On the other side, project controls definition by the AACE International is “management action, either preplanned to achieve the desired result or taken as a corrective measure prompted by the monitoring process”. Project controls are mainly concerned with the metrics of the project, such as quantities, time, cost, and other resources; however, also project revenues and cash flow can be part of the project metrics under control.

In reality, both terms define a profession that is an application of quite the same body of knowledge. In board terms, we could define the project profession as the comprehensive group of professions related to any project, starting from the idea and the feasibility study and following the whole life cycle: designers, project managers, project controllers, planners, cost engineers and so on.

In the same way, the legal profession includes for lawyers, solicitors, barristers, notaries as well as the medical profession includes for surgeons, cardiologists, oncologists, etc.

2 Some words used in TCM profession

Project
The word originates from the Latin verb PROICIO, that means to throw forward, PROIETCTUM is the neutral past participle, meaning “that has been thrown forward”, from there the Italian words proiettile (projectile, bullet, shell) and progetto (project).

There is then a correspondence between English project and Italian progetto. However, in Italian the word progetto normally refers only to the paperwork resulting from the activities performed by the engineer or the architect, such as the production of a group of drawings, specifications and bills of quantities at different levels of detail, then corresponding to English design and engineering.

The word can also be referred to personal matter, without any relationship with engineering.

To this point, it should be noted that the English word “project” is someway broader, since it is not limited to defining an idea expressed in an aggregate of drawings and specifications, but is extended to the whole of the activities from the procurement of financial assets procurement of materials, construction and testing.

We then have words that are lexically equivalent while semantically different, the risk in that a native Italian speaker, when speaking in English, can confuse the meaning. See the table of correspondences here below

<table>
<thead>
<tr>
<th>ENGLISH</th>
<th>ITALIAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Opera</td>
</tr>
<tr>
<td>Design</td>
<td>Progetto, progettazione</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
</tr>
</tbody>
</table>

Programme, plan, schedule

The word “programme” or “program” originates from late Latin “PROGRAMMA, -ATIS” that is a loan from greek πρόγραμμα, -ατος, from verb προγράφω, “write before”. The original meaning refers to a written document with a statement of something the author is willing to do in the future.

The word “plan” originates from latin PLANUM, the original meaning is referred to a flat surface. Due to the use of sheets of white paper, the meaning was translated to the drawing itself, and then to a “detailed and systematic formulation of a large scale programme”. Further derivatives are “planning” in English and pianificazione in Italian, that is probably due to a re-import from English to Italian.

The word “schedule” originates from latin “SCHEDULA”, whose original meaning is slip of paper or papyrus, then card. Then the meaning was translated, in English, to a written list of actions to be done, the corresponding word schedula is seldom used in Italian.

In our terminology, the correspondence is as below
It's easy to understand how the word “programme” can be source of ambiguity in Italian as well as in English spoken by Italian people.

**Controls**

The word originates from French contrôle, from contre rôle or contrerolle, whose original meaning was counter-register, namely the copy of a register. The English meaning then diverged from the original meaning, that was kept in French as well as in Italian.

As a matter of fact, while the English term identifies a procedure that is active during the whole life of the project, comparing from time to time the achieved to the planned, defining both efficiency and effectiveness and from then calculating an estimation to complete together with relevant deviations in order to identify corrective actions, if any, the French and the Italian word are relative to a check performed after the works is completed, to verify its conformity to the contract and to point out any difference. When project controls have been introduced in Italy the Italian word controllo has actually assumed the double meaning, while in French the term used has been maîtrise de projet.

**Monitoring**

The word originates from the Latin verb MONEO, whose derived names MONITIO and MONITOR are referred to an advisory action as well to the action of reminding about action to be done or to expiry dates. In modern terminology, for “project monitoring” we mean an action that is quite similar to project controls, albeit performed on behalf of other stake-holders in an advisory way, without any power of interference. Paradoxically, the word monitoring has been reimported to Italian as monitoraggio, while the correct term should be monizione, that is actually used in legal documents but never in professional papers.

**Auditing**

The word originates from latin verb AUDIO, whose derived name AUDITOR is referred to a disciple as well as to a trainee, the word was used in Italian (uditore) to define the trainee in judiciary career, that was acting as assistant to the judge in charge.

In English, the meaning has been “assistant”, that is actually coherent with the original one. The verb “to audit” with the meaning of “examination or verification of accounting books” actually derives from Latin “AUDIENTIA”, Castilian audiencia, as the act of hearing, referred to the hearing of subjects from
a governor or from a judge. This meaning has been then re-imported from English to Italian, keeping the word as it was, while it would be better to use other words, such as vigilanza.

**Total Cost Management**

In the majority of Common Law countries, Cost Engineering and Project Management have had a separate development, like two fully independent disciplines. The relevant professions are separate, like in England, in the majority of the Commonwealth countries, in the United States of America.

In countries belonging to the Civil Law group of countries, namely in most of countries of continental Europe, the profession of Cost Engineer, Planning Engineer and Project Manager have had a common and sometimes confused development. This can also be understood from terminology: while in English speaking countries we have different definitions for Cost Engineering, Project Management, Planning Engineering, Quantity Surveying, Construction Economics in Latin countries the overall term of Ingegneria Economica (Ingeniería Económica, Financiera y de Costos) has been used since the beginning. This overall concept has been accepted in 1998 also by the ICEC, as Total Cost Management, whose meaning is corresponding to the meaning of Ingegneria Economica, as far as the different languages will allow the correspondence. The Total Cost Management (Ingegneria Economica) is a discipline that integrates cost engineering; contracting; construction economics; planning, scheduling, controlling; engineering and project metrics.

It is worthy to point out that, besides being involved in Project Controls, the main field of Total Cost Management is evolving towards lifecycle or capital asset management, investment decision making, profitability and business planning.

It seems that we have several professions insisting on the same body of knowledge, albeit with different competence baselines. Such professions, that are listed here below, are partially overlapping each other and probably some simplification is needed: Project Director, Project Manager, Project Engineer, Project Comptroller, Planning Engineer, Cost Engineer, Contract Engineer, Contract Manager, Programme Manager, Project Monitoring Consultant, Project Auditor, Quantity Surveyor, Construction Economist, Asset Manager, Cost Manager.

As far as Total Cost Management is concerned, it would we worthy to introduce a new terminology to cover from one side the discipline and from the other side the profession. A proposal could be to define the discipline as Project Economics and the profession as Project Economist.

### 3 Conclusions

When moving from a language to another, there is sometimes a semantic difference between words that are lexically equivalent. Furthermore, in any language, the same word can have different meaning when used in different context.

We need to take care, when translating or speaking in a language that is not our mother tongue, even in case we are enough fluent, in order to know exactly the meaning of the words we are saying, to
avoid any misunderstanding.

When writing, it is advisable to explain the meaning we are giving to a controversial term, even in case we are writing in our own language, like we are normally doing when writing a contract. Ancient theological books opened any matter with the EXPLICATIO TERMINORUM (explanation of terms). The intent was to avoid any possible misunderstanding in the use of terms that may have unique meanings, similar, but also quite different.

It is of paramount importance, however, to realize that there are semantic problems both within the associations as well as between the associations and the market, so that often we say the same thing, but without full mutual understanding. In addition, a fixed point is to safeguard the fact that the profession, although unitary, must preserve the identity of the various components, just as other professions and para-professions are doing.

We believe that, in the near future, the whole project profession shall be internationally represented by a single federation or confederation of all the related professional associations.

This confederation, if the relevant project will go on, will also have some side effects that are described below.

1. There is, even in the professional environment and even more in industry and in the market, a lack of understanding of the various certifications, so different certifications are considered equivalent, with clear disadvantage for the highest levels of certification: a policy of mutually agreed comparison between the certifications and their levels may help.

2. The possibility to create certification paths (and hence career paths) with one or more points of contact and transition from one type of certification to another. This means that those who wish, for example, move from ICEC to IPMA certification or from IPMA to ICEC, can obtain that the level reached be recognized instead of starting again from the beginning.

3. More attention to the training and guidance, an appropriate balance between generality and specialization, increased attention to continuing professional education.

4. More attention to market trends.

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i http://www.merriam-webster.com/dictionary/semantics

ii SEMANTICA EST RAMUS LINGUISTICAE QUAE CURAT DE VARIATIONE SENSUS VOCABULORUM IN TEMPO ET SPATIO

iii As a cultural reference, in Latin we could say: OPERIS GESTIO (project management), OPERIS GUBERNATIO (project controls), INPENSARUM GUBERNATIO (cost control)
iv Probably, project management and project controls have quite the same body of knowledge, while differentiation exists in competencies and their application to the profession. Total Cost Management, however, has a wider body of knowledge.

Project controls has more to do with project metrics, such as measuring site and complexity of the project, find the right parameters for such measuring (workload in standard man-hours or equivalent units, location factors and other indicators) and controlling (progress, time and costs, find proper indicators for quantity and complexity), find the metric way to identify the completion of the various phases such us mechanical completion, running and reliability test completion, substantial completion, preliminary and final handing over), identify the metrics for contract and claim management and so on.
An engineering approach to economic development
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ABSTRACT
A lot of theories and consideration have been written up to now on economic development, mainly by sociologists and economists. The purpose of this paper is to analyze the problem from an engineering point of view, focusing on quantitative aspects as well as try to point out some conditions under a proper equation, namely shifting from words to figures.

Useless to say, mathematics will never govern the economy, since the behavior of human beings is never perfectly rational, however some mathematics can help.

Keywords: economics, development, growth, statistics

1 Foreword

A lot of theories and considerations have been drawn from past to more recent times, on the economic development: in general, this has been the work of economists and sociologists, sometimes of historians.

These theories express completely different points of view, from an extreme optimists, which are often not able to give sufficient reasons for their optimism, or, on the other extreme, the prophets of doom, locked in their ideological presuppositions, not even bother to rationally justify their gloomy prophecies.

This research analyses the problem from a different perspective, that of an engineer, who, by nature and training focuses on a quantitative approach, with greater attention to the quantities and to the figures, trying to solve difficulties by analysing in the form of an equation. In plain words, shifting the focus from words to numbers.

While recognizing that, unlike engineering, economics is not an exact science, because it must take into account the irrational behaviour of human beings, we believe that mathematics and quantitative analysis are important as they can help in defining the necessary conditions, not always sufficient, to achieve a goal.
We are living in a time where economic development is badly considered, a lot of people thinks about economic decrease supposing that the standard of life of the next generations will be worst than ours, by reversing the very concept of progress without giving any rationalisation to their pessimist attitude. This is very common in Europe, where majority of people is now used to cry on themselves.

Situation becomes even more confused since generally the matter is considered under a political point of view, without considering the scientific approach or taking into consideration only those scientific data that support the view of the politician. Mass media add further confusion, sometimes in good faith.

An engineering approach will not solve the political problem, our aim in only help to understand what economic development means.

It is not for economists or engineers to decide whether economic development is good or evil, this is a political matter. However, once it has been defined, economists and technicians have to define the conditions to be met and actions to do in order to implement the choice and achieve the goal, as well as the impediments to be removed, and to calculate costs and benefits both in monetary and real terms.

We like to remind a statement from Pope St. John XXIII, on the introductory speech to the opening session of the Ecumenical Council Vatican II:

**(4.3)AT NOBIS PLANE DISSENTIENDUM ESSE VIDETUR AB HIS RERUM ADVERSARUM VATICINATORI-BUS,QUI DETERIORA SEMPER PRAENUNTIANT,QUASI RERUM EXITIUMINSTET.**

Whose translation is: “We seem to have to fully disagree from these prophets of doom, who always proclaim the worst, as if the end of the world would be coming”

Economic development is a long run matter, then we have to define what we mean for long run, that is a different definition from that we can find elsewhere, in other fields of science.

Namely, we define:

- **Short run**, the time span corresponding to the electoral cycle that, in democratic countries, varies from 3 to 7 years. We can assume a conventional value of 5 years.

- **Medium run** is the average duration of human life or the three to four generation time span that is needed for a family to really change is social status and behaviour or to be assimilated in a country different from that of origin, namely a time span from 70 to 120 years. We can assume a conventional value of 100 years.

- **Long run** is related to the life cycle of a nation or of a civilisation, to the duration of an empire or of a national state: it is the historical time, the time span to be considered is quite difficult to determine, it has to be measured in centuries.

There is an analogy with the theory of economic cycle, that is also articulated into two levels, the short term whose first description is found in the Holy Bible (Gen 41, 2-7) and, in recent times, that has been studied by all major economists, and whose duration can be compared with the short run defined above.
and, the longer term sometimes called super-cycle, first described by the Soviet economist Kondrat'ev, whose duration can be compared with the medium run described above.

2 History and roots of the economic growth

Either we like it or not, the economic growth has been a peculiarity of the Western European civilization, starting between the X and the XI century after Christ and later on exported to other parts of the world.

Among the factors, we should consider that the Western European culture is an integration of several cultures:

- **ancient Greek**, that gave the basics of science and philosophy together with the structured thinking, furthermore the Greek culture has been a connection factor with the Middle Eastern cultures (Assyrian, Sumerians, Babylonians, etc.) as well as with the Egypt

- **the Roman culture**, whose heritage are the very concept of law at all levels, from constitutional law to civil, international and criminal law, together with the concept of organization, either in government or in military. All juridical systems that exist now still can be divided into two big areas that are commonly known as:
  - **Civil Law**, that evolves from the Roman and feudal law to the modern law, through the canon law and then through codification process; the Civil Law is the continuation of Roman law, the starting point has been the **CORPUS IURIS CIVILIS** (529-534)
  - **Common Law**, that also derives from Roman law, although in its most ancient form, and evolves in England without the mediation of the CORPUS IURIS CIVILIS; it is mainly based on case law and is the basis of the law in all the countries of the Commonwealth and, in part, in the US, where in fact there is a mixed system. The common law was primarily a creation of the judges, then sanctioned by the royal power; in a certain sense, it is closer to the ancient Roman law than the Civil Law.

- **Judeo-Christian**, whose heritage are
  - a religion based on a personal God as well as a linear conception of timeline,
  - trinitary theism, that has been important for the development of the European civilization in all its aspects, while the Christological dogma of Calcedonia (451) has been important on the institutional point of view
  - the dispute between Pelagius (360-420) and Saint Augustine (Aurelius Augustinus Hipponensis-354-430), with its anthropological consequences, among them the distinction between rightist and leftist politics, that is anthropological before being politic
  - We should not forget that the very word Europe had different meanings in the past, and it’s used for the first time with the modern meaning when emperor Charles the Great was defined **REX AC PATER EUROPAE** or **EUROPAE VENERANDUS APEX**.
  - However, until the XV century, would you ask to anyone “Where we are?” the answer would have been “We are in the Christianity”.

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• **Germanic culture**, whose heritage can be found in the concepts of freedom and feudal or anyway territory related nobility

• **Others**

The Romans in the I century after Christ and the Indians in the XVI had created a good deal of the preconditions for economic growth, however such growth, albeit started, did not develop. As far as the Romans are concerned, the main reasons have been the so called trap of slavery as well as the lack of a suitable source of energy.

The quantitative analysis is a fundamental tool to understand what happened, however it’s only an auxiliary instrument to make decisions and to foresee the future, this is due to:

◊ the irrational behaviour of human beings, individually and collectively

◊ the limits of any model that, although seems to have credibility due to the use of mathematics and statistics, will never be more reliable that the theory that his behind it

◊ the unforeseen and unforeseeable events (the so called black swans)

Statistic are also important; however, a statistic correlation between two variables, albeit being an important tool to understand whether there is a real dependency between them, has to be completed with thoroughly investigation aiming at knowing with reasonable certainty, the reality of such dependency.

As a matter of fact, correlation of variables related to events does not mean that there is a relationship of cause to effect. This is especially true in case the events are concurrent in time.

Let’s bring forward as couple of examples:

• according to Max Weber, the economic development is a consequence of Protestantism but, other scholars that have made a deeper investigation into the economics in Middle Age now believe that the Protestantism has been a consequence of economic development

• apparently there is a correlation between population of storks and number of births

Also when a causal relationship exists, could be difficult or controversial to decide which is the cause and which is the effect that are sometime concurrent in the long term, as the above example on Protestantism shows.

3 The economic systems

In human history, economic and social systems have been subject to ups and downs; in the first place the transition from a subsistence economy to an economy of accumulation and finally to an economy of consumption;
In addition, in some historical periods, it predominated a local view of the economy while at other times there has been a wide interdependence of the various economy, both visions being possible either in market or planned economy: the world since the second half of the nineteenth century until the early twentieth century was no less global than the world today, and probably the same can be said, at least for a few centuries, for the Roman Empire.

Some examples can be found in the table here below.

<table>
<thead>
<tr>
<th>Relationship with other economies</th>
<th>Planned economy</th>
<th>Mixed economy</th>
<th>Market economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locally closed</td>
<td>Manorial and feudal economy from V to X century</td>
<td>Europe XI to XVI century, India XV to XVI century</td>
<td></td>
</tr>
<tr>
<td>Nationally closed</td>
<td>Socialist economy after WW2, USSR economy before WW2</td>
<td>Europe XVII century, Europe 1920-1980 (corporative or keynesian economy)</td>
<td>Occidental free market economy 1920-1980</td>
</tr>
<tr>
<td>Global (worldwide or continental) economies</td>
<td>Roman empire (late), eastern empires</td>
<td>Roman empire</td>
<td>Europe XIX, XX century before 1914 and after 1980, XXI century</td>
</tr>
</tbody>
</table>

A further classification is between static and dynamic economies: while the growth can be present, by definition, within a dynamic economy only, this does not mean that level and quality of life are necessarily better. In the above table the dynamic economies are identified with the red colour, while the static economies are identified with the blue colour: this is a very rough classification that needs further investigation.

A further classification is between planned and market economies; in the table below, a classification that takes into consideration the property rights and level of planning is represented. To identify an economic system along the axis that goes completely planned economy to the free market have been identified semi-quantitative measurement criteria, such as those of the Research and Documentation Centre “Luigi Einaudi”.

![Economic Systems Diagram](image-url)
4 Conditions of the economic growth

While causes and conditions of economic growth are interrelated in several ways and then is quite impossible to have a complete understanding, it's worthy to take into consideration, in a summary and not complete list, some of them.

Also has to be considered the so called eterogony of ends (eterogenesi dei fini): this principle, namely the study of “unintended consequences of intentional actions” was first described by Nicolò Machiavelli (1469-1527), albeit a more detailed theory can be found later on, in Giambattista Vico (1668-1744) as well as in Wilhelm Wundt (1832-1920). The concept of the invisible hand proposed by Adam Smith (1723-1790) is quite similar.

1. Geography, climate, environment: useless to say, economy can develop only in a favourable environment, there is no growth in the desert or Antarctica.

2. Religion and Philosophy have an important impact that needs a very thoroughly analysis. Related to them, there is the philosophy of time that in human culture until recent time could have been either linear, like an arrow from the past to the future (due to the Judaic and Christian culture) or circular, with an eternal recurrence of events (a lot of Indo-European cultures, including Persia, India and ancient Greeks, while the Romans were swinging from one to the other. A circular concept of time was also present in the Maya and other pre-Columbian cultures) However, we can affirm that the concept of linear time, that is originated from the Judeo-Christian culture, is pre-condition of any economic development.

3. Ethics

4. Ideologies or dominant ideology

5. The state has not to be a monolithic entity, there have be diversification and availability of alternatives, research in any field and sound innovation have to be sustained and accepted.
   a. Christopher Columbus (1451-1506), when rejected by the King of Portugal, could apply to the Queen of Castile and discover America.
   b. Zheng He (1371-1434) explored the whole Indian Ocean, but xenophobia and isolationism typical of the Confucian culture of the time blocked any further exploration, so China lost the train of development.

6. Time span of political vision: the economic development need a long term vision, this is why some democratic systems are at risk of failing, since their vision cannot go beyond the electoral cycle.
   a. In the past, the presence of hereditary kings and nobility have been a factor that has indirectly guaranteed long term vision together with safeguarding the permanent interests,
   b. the challenge now is to find a way to integrate long, medium and short terms actors, namely to integrate the various form of government, as it was already clear to Cicero (Marcus Tullius Cicero, 106-43 before Christ)
   c. The emphasis on “sustainable growth” is a clear indication that we are used to think with a very limited temporal vision. In the long run this concept does not make any sense: either there is development or not.
7. Knowledge capital: in the long run, a nation’s prosperity is directly related to the cognitive skills of the population. The cognitive skills can be measured by performance on international mathematics and science assessments, years of scholarship are not a sound indicator. To be noted that, according to the studies completed up to now, a general curriculum of studies seems to be better than a vocational one.

8. Demography: a moderate increase of the population is a precondition of economic growth, a static or decreasing population definitely hinders the process of economic growth, while a population that grows too fast can also create problems.

9. Property rights and legal system: the property rights must be defined and guaranteed by the law, the heritage rights too must be guaranteed by the law, the legal system has to be well defined and easily enforceable in acceptable time.

10. Fiscal system has to be defined, easy to understand and manage, related to the economic system without neither distortion effects nor limitations of economic freedom. The fiscal pressure has to be limited, so that it is felt as a contribution, not as an expropriation.

11. Political stability

12. Economic Freedom: free enterprise, free choice of the work, no work assigned by authority, no slavery or forced labour. Other conditions related to the economic system are
   a. adequate productivity in agriculture and a minimum level of efficiency in the other sectors.
   b. educated labour supply and capital.
   c. demand for industrial products.
   d. availability of entrepreneurial skills.

13. Political freedom: this is a controversial point that needs further investigation. Amartya Sen strictly related development and freedom, however we cannot deny that, in some cases, substantial economic growth, with dictatorial or semi-dictatorial governments, albeit at an higher price.

14. Personal freedom: to be kept within defined limits, in order to avoid de-structuring the society

15. Monetary: as far as the economic development is concerned, one key factor is the availability of money, while an excess of money could hinder the process. The past standards (silver standard, bimetallic standard, gold standard, gold exchange standard) are over, on the other side the so called “fiat money” has also created heavy speculative problems and exalted the economic cycles.
   a. Some economists believe that money should be related to a defined basket of real goods, other economists support to go back to an updated version of the gold standard.
   b. The main argument against the gold standard is that it favours countries that have gold mines. However, that argument is valid for all raw materials, not only for gold.
   c. Other proposal, such as an energy standard, have been brought forward.
   d. A slight inflation favours the economic development, while both deflation or high inflation hinder it.

16. Profit and interest rates: useless to say, profit rates have to be higher than interest rates.
17. Market economy seems to be better than planned economy, however we cannot deny some cases where an economy grew under planned system. While we respect the thoughts of the Austrian economist, we must accept that the market has to be adjusted in those cases where distortion elements are present.

18. Global economy seems to be better than closed or protected economy, at least in contemporary and other historical times, while this is not true in other periods. This point needs further investigation.

19. Availability of infrastructures: since ancient eras (Egyptians, Babylonians, Romans) infrastructural and public work have been considered among the activities of a sovereign state, that can perform them either directly or indirectly, through privates or in partnership with them. However, it’s the State that has to assure that the infrastructures or the relevant services be available to all citizens either free of charge or at a price subject to proper regulations. In modern times, the infrastructures consist in:
   a. energy supply (gas, electricity)
   b. water supply
   c. transportation
   d. communications
   e. sanitation and waste
   f. drainage and flood protection
   g. schools
   h. health service

20. Social system that allows the possibility of social escalation, with guaranteed heritage rights. As far as the heritage rights are concerned, a further investigation could define whether, on development point of view, it is better a full guarantee or a limited guarantee, where “the heirs must justify, with their skills, the right to the preservation of inherited assets” (in reality, this is achieved through inheritance tax which, however, should not be an expropriation of assets).

21. It is not clear how income distribution can affect the economic development, apparently it has to be neither equalitarian nor too unjust. According to some scholars, it means a value of the Gini coefficient from 0.30 to 0.60, according to others from 0.25 to 0.40. Probably, it would be better to shift the emphasis from income distribution to the production of the same income; perhaps, instead of insisting on inequalities, it would be better to insist on the need for a decent standard of living for the most disadvantaged, leaving the distribution to the natural adjustment of the economic system. Otherwise we are at risk of fighting the wealth instead of fighting poverty.

5 Quantitative approach

Majority of data used in economics are based on monetary values, then they can be distorting, either if referred to different countries or to different times. The most popular index to measure the economic development is the GNP, however it would be better to use purchase power parity (PPP) that can be calculated, albeit not perfectly due to difference in terms of exchange, mainly in the long run. There are other
auxiliary indices to measure the development, such as the human development index (HDI) or infant mortality, as well as technological indices such as the capability to measure time with increasing precision.

While we understand than to use the GDP as measure of the economic development is not the perfect way, we must accept that, for the time being, it is the only suitable way to do it. Other indicators, such as the proposed gross national happiness (GNH) as well as the genuine progress indicator (GPI) proposed by green economists, are based on subjective aspects and then are not a real measure.

It is also to be reminded that a lot of different formulas have been proposed in order to calculate the global power of a nation. Some of them take into account a lot of parametres and are quite difficult to manage. The Indian economist Arvind Virmani has proposed a simplified way to calculate the national power potential (NPP) as

$$\text{NPP} = P \times y^a$$

where

- $P$ is the population
- $y$ is the pro capite GDP at purchasing power parity
- $a$ is a coefficient whose estimate value is 1.5 to 1.6

A very important contribution to compare the GNP of the economies from different centuries has been given by Angus Maddison (1926-2010), under the auspices of the Organisation for Economic Co-operation and Development (OECD). His main work on that matter is the book "The World Economy: Historical Statistics", published in 2004 by the OECD Development Centre, that studies the growth of populations and economies across the centuries. His colleagues are continuing is studies under the Maddison Project.

Quantitative data can give a substantial help in understanding the status and the performances of the real economy, together with the possibility of growth or the risk of decrease.

A quantitative approach or, as we like to say, an engineering approach, is needed in several fields of the human science. Mario Silvestri (1919-1994), who actually was a nuclear chartered engineer as well as a lecturer on nuclear power plants at the University of Roma, through his side activity of history scholar, introduced the quantitative approach in historical studies and gave an important contribution to the understanding of European history relevant to the period from 1890 to 1946.

Let's have a look to some examples that can explain what we actually mean for engineering approach.

**Average temperatures**

The first graph shows the average temperature from 3500 before Christ to now. While it is quite clear that we are facing a climatic change, whose causes are still controversial, a look of the graph let us know that the economic development took place in high temperature periods, such as Roman age and Medieval optimum.
Price of energy

The second graph shows the price of energy and energy services from 1300 to 2000 after Christ. While is common opinion that the energy prices is rising, a look to the graph shows that this raise in only true in monetary terms. Furthermore, this graph can let us understand, albeit partially, why the industrial revolution succeeded.

Figure 11. Average Price of Energy and of Energy Services (Heating and Power) in the United Kingdom (1300-2000)
Energy intensity

The third graph shows the energy intensity in some European states from 1820 to 2002. Besides the peculiarity of Sweden in the XIX century, from the aggregate curve we know that the energy intensity has decreased from about 20 to about 10 MJ/$. The aggregate energy intensity includes Britain, France, Germany, Italy, the Netherlands, Portugal, Spain, and Sweden. Prices are in constant international dollars, calculated at PPP (purchasing power parity) in 1990.

It is understood from there that energy efficiency is quite doubled in two centuries: this allow us to foresee the real constraint imposed by the availability of energy to the growth and how the importance of this constrain has been decreased and, hopefully, will be subject to further decrease in the future.

The fourth graph, however, shows that still there is a long way to reach an energy efficient economy (to be noted that the units used for measurement are different from the previous graph).
Energy consumption

The fifth graphix shows energy consumption. It is self-explanatory.
Efficiency of lighting

The sixth graph shows the efficiency of lighting in the United Kingdom from 1700 to 2000, whose value in lumen-hours per kWh raised from 28 to 25000, namely in the relation 1 to 893. To be noted that a further increase has been experienced from 2000 to now, due to the diffusion of LED lighting tools.

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<thead>
<tr>
<th></th>
<th>Candles</th>
<th>Whale Oil</th>
<th>Gas</th>
<th>Kerosene</th>
<th>Electricity</th>
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<tr>
<td>1700</td>
<td>99%</td>
<td>28</td>
<td>1%</td>
<td>20</td>
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<tr>
<td>1750</td>
<td>95%</td>
<td>29</td>
<td>5%</td>
<td>21</td>
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<tr>
<td>1800</td>
<td>90%</td>
<td>37</td>
<td>10%</td>
<td>56</td>
<td>68</td>
</tr>
<tr>
<td>1850</td>
<td>21%</td>
<td>76</td>
<td>1%</td>
<td>76</td>
<td>78%</td>
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<td>1900</td>
<td>1%</td>
<td>80</td>
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<td>82%</td>
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<td>1%</td>
<td>887</td>
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<tr>
<td>2000</td>
<td>100%</td>
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<td>25,000</td>
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</tbody>
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Source: authors’ own estimates – see Section 2 on data for details.

* Efficiency is presented in lumen-hours per kWh.

** These estimates ignore the proportion provided by fish and vegetable oil, and from indirect sources, such as cooking and heating fires.

Efficiency of thermal machines

The seventh graph shows the increase in efficiency of thermal machines, from less than 1% to 50% about. It is worthy to note that, while it’s clear the relationship with the industrial revolution, in difficult to decide about which of them has to be considered on the cause side and which as an effect. Another case of concurrent events.
Time measurement

The eighth graph shows the increase in precision in measuring time. Precision in measuring time has a strict relationship with progress: the Romans were measuring time only through sun-dial, sand-glass or water-clock, the famous clock that was sent, as a gift, by Harun al-Rashid to Charlemagne in year 807 after Christ was still a water-clock. Mechanical clock, that really allows people who could afford it to know the time, was introduced in XII century.
Salaries

The ninth graph shows the relationship between population and real salaries.
The tenth graph shows the prices of a car and of a day in an hospital calculated in Man-hours of corresponding salary. This is another demonstration of the distortion than can be obtained with the only use of monetary figures.

Unfortunately, statistic data for the past are quite rare, with the only exception of the United Kingdom where more information can be found, starting from Domesday Book (1086).
**Efficiency in agriculture**

The black line on the eleventh and last graph shows the increase in efficiency of grain production in agriculture, by giving the actual number of produced grains for each grain sown.
The ratio was 4:1 at the golden era of Roman empire, then decreased to about 2:1 after the fall of the empire. It started then to increase again up to a value of 30:1 in year 2000.

6 The Catholic Social Teaching

There is a problem in understanding on the part of economists, the Catholic Social Teaching as well as the proposals derived from it.

Any scholar realizes that the social teaching regards ethical issues, while it does not propose economic models: however, at first sight, it could appear that, many proposals, if applied, would not give the de-
sired result, but produce an opposite effect. The economists fail to understand why there is a separation between the principles enunciated by the Catholic Social Teaching and the current economic theories.

The Italian economist Luigi Pasinetti (born 1930) has dealt with the issue, saying in his final reflections that we should reach some conclusions that cannot be incompatible with each other.

He highlights the limits and the current problems of economics, leaving to the theologians to deal with the incompatibilities and concluding that “economic theory is going through a very critical period, which really requires a strict and radical reconsideration of its foundations. ”

In our opinion, a substantial part of the incompatibility we are speaking about is due to pure semantic issues, which deserve to be examined more closely.

7 Conclusions

There is a need to promote the rationalization of human behaviour, always existed in history, but particularly felt since the 90s of XX century, when the strong feeling of the crisis and the consequent affirmation of an arrogant relativism, together with the enormous and uncontrolled availability of information, have caused great confusion of consciences.

We will not discuss here the philosophical aspects: we want to limit ourselves to some application tips applicable to various fields of human activity, and in particular to land management, execution and management of infrastructure during their entire life cycle.

The starting considerations regard the history of the economy over the centuries:

- the transition from a subsistence economy to an economy of accumulation and finally to an economy of consumption let us understand that we must now achieve the creation of an economic system that balances the needs of consumption and investment.

- In addition, in some historical periods, the view of the economy was local while at other times there has been a wide interdependence of the various economy: in reality, the world since the second half of the nineteenth century until the early twentieth century was no less global than today’s world, and the same can be said, at least for the first and the second century after Christ, for the Roman empire.

- It is now essential to achieve integration between the local dimension and global dimension, because only in this way it will be possible to produce locally those goods and services which are not exposed to international competition, achieving the efficiency gains that are possible by applying methodologies already widely in use for goods or services produced globally.

- It would help a worldwide scientific platform for methodological and technological innovation, based on information sharing and shared responsibility of all actors.

It is worth at this point, to add some considerations and details:

1. The evolution of economic systems based on the integration of the local economy and the global
economy makes it essential to adopt appropriate land management tools and protocols that help to provide, manage and adjust, if necessary, the market mechanisms. In this perspective of integration can be framed:

a. land management, from limited areas, extending gradually,

b. the construction and management of infrastructure and production facilities,

c. the management of urban heritage, cultural heritage in general and of cultural heritage in particular.

2. Today there are mathematical tools (quantitative methods, statistics, etc.) and information systems that allow the complete knowledge of all the information and data related to economics, with particular reference to a system or economic subsystem on a given territory. Those tools will not allow to fully govern the economy, due to the irrational behaviour of human beings and communities, however they can improve the management of economics. Furthermore, the same tools allow various calculations and simulations that can enable us to do a proper preparation to be able to react to unforeseen events.

3. We must learn that in any system or local economic subsystem there are multiple production processes, where different actors (producers, processors, distributors, consumers, investors, standardization and regulation authorities, etc.) should act in an integrated manner, as components of a system and not as opposing parties who pursue only their particular interest; the same holds true for infrastructure projects or investment.

4. The development of project finance allows to overturn, at least in part, the traditional investment process and therefore offers new opportunities for economic development; whereas in the past it was necessary the accumulation of capital in order to proceed with the investment, it is now possible, in some cases, obtain the capital from future funds to be derived once the investment goes into operation without any other warranty if not the project itself. Hence the need to integrate the management and control along the whole life cycle of the project.

5. The introduction of associative contractual mechanisms, where applicable, allows you to switch from one system to opposing parties, where each party tries, legitimately, to make most of their profit without sufficient attention to the total cost of the project, to a system based on association whose goal is the optimization of the total cost through a systemic view, acting on the total income and the distribution of income among the actors in a concerted manner.

In conclusion we can say that it is required a transition from a short-term vision (corresponding generally to the electoral cycle, five years) to a medium and long term vision, that takes into account the interests in the long term, also called "permanent interests", in other words the interests of those who are not yet born and those who do not live any more, in a perspective of centuries and not years.

Today, unlike in the past, there are information tools, management and control that allow us to also address long-term problems in a rational manner. The enormous capacity of information systems and communications network can and should be used for human development in all its aspects.
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i The “market socialism” is a hypothetical system proposed by the economist Ota Šik in the ‘60s.
ii The sociologist Max Weber famously argued that religion can influence economic performance through its effect on character traits such as the work ethic. Barro and McCleary subject this view to a rigorous test. As with Barro's earlier work on growth, the unique aspect of this research is the painstaking assembly of a new data set, in this case the data on religious beliefs and attendance at formal religious services drawn from six international surveys covering about fifty countries.
Barro and McCleary find that countries in which people have stronger religious beliefs, as reflected in a stronger belief in heaven and hell, have higher economic growth—a finding consistent with Weber's thesis. However, once the impact of religious beliefs on economic growth is accounted for, greater attendance at formal religious services lowers growth. So attendance matters to the extent that it influences beliefs, but beyond that it uses up time and resources that detract from growth.

iii In modern times, more sophisticated theories have been proposed such as the idea of time as a spiral, that can combine recourse and progress (Vico, Hegel, Marx), while the German philosopher Nietzsche proposes again a cyclic idea of time. The idea of time in the theory of relativity shows some analogies with the spiral.

According to Saint Augustin of Hippo (354-430), time has been created by God and then is linear, the eternity that runs. He makes a distinction between eternity (present without time) and perpetuity (endless time).

iv Source: Marabini, 2007 – the matter is extremely controversial due to scientific as well as political reasons, however the graph shows a possibility of correlation between higher temperature and economic growth.


vi Energy intensity for Europe 1820–2009, MJ/international dollar in 1990 prices. The aggregate energy intensity includes Britain, France, Germany, Italy, the Netherlands, Portugal, Spain, and Sweden. Prices are in constant international dollars, calculated at PPP (purchasing power parity) in 1990.

vii Reference is made to the so called dollar Geary- Khamis, that in this case is the international dollar in 1990 prices.

viii From Wikipedia

ix The long run energy consumption in Europe 1500–2010 in relation to three industrial revolutions (GJ per capita). The sample includes Britain, France, Germany, Italy, the Netherlands, Portugal, Spain, and Sweden. The circles indicate the main technological influences on the changes in energy use associated with each revolution. There was also some continuity from older developments during these revolutions.
Seven Centuries of Energy Services: The Price and Use of Light in the United Kingdom (1300-2000) - Roger Fouquet* and Peter J.G. Pearson** - To be noted that after 2000 the efficiency of lighting has been subject to further increase due to the introduction of LED lighting.

Source: Sergio Ricossa – L'Economia in cento grafici – EST Mondadori, 1984
Equitable payment and social inequalities

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ABSTRACT

The problem of properly defining the equitable payment for different levels of work has been discussed since longtime, reference should also be made to a proper scheme of comparison of the work level in different organizations, starting from the basic theory of the “time span of discretion” defined by Elliot Jaques immediately after the second world war and still subject of discussions and consideration. Also we shall set up a model trying to justify why a difference in payment for high level and lower level works can be easily accepted in a so called “rich country” while it cannot be accepted in poorer countries.

As a matter of fact, the necessity to measure and compare job levels in different organisation is known since very old times, the first important attempt we had in the history is the NOTITIA DIGNITATUM in the late Roman Empire, and similar schemas have been tried in several cases, generally without proper quantitative and statistical methods.

Starting from 1950’s, in the general framework of the organisation theory supported by the Tavistock Institute, the psychologist Elliot Jaques together with the industrial manager Wilfred Brown started a new research trying to find a proper quantitative parameter to measure the job level and to set up a criterion for equitable payment. The research (Glacier Project, 1950) was followed by further studies on the British National Health System (Rawbottom, Billis) and other studies until the research of Ivanov (2006).

The result is that job level can be measured with a proper parameter whose name is “time span of discretion”, that this parameter can be uniformly used in any kind of organisation and eventually that it is related to the equitable payment related to the job itself.

The paper shows the history of the research, its result and its possible future developments and describes some application and possibilities related to the Italian case.

Keywords: organisation, time, job, level, payment, subordinate, manager, hierarchy
1 Foreword

The study of the organization is a typical multi-disciplinary study.

In the “outline of knowledge” of the ENCICLOPAEDIA BRITANNICA, that is a linear classification, not entirely suited to classify disciplines at the intersection of other subjects, the study of organization is placed in the part called “human society”.

In a matrix classification, the organization may be located at the intersection of

- legal disciplines relating to the organizational and institutional aspects, with particular regard to canon law and to the comparative constitutional law, as well as to the company laws and the domestic and international commercial law;
- technical disciplines, economics, finance (technology, economics, finance) relating to the production and distribution of goods and services,
- sociology and communication science,
- psychology.

The study of the organization, in modern terms, also need adequate numeric methods and operations research.

The need to organization starts with the beginning of human civilization, namely in the Neolithic period, when man begins to settle and therefore to constitute urban agglomerations; it is well known that the oldest sovereign state organization is the Egyptian Kingdom together with the Sumerian city-states.

A further reference to an organization based on the delegation is in Exodus 18: 21-22; we are at the time of Moses, therefore, according to current opinion of Biblical scholars, around 1200 BC: at about the same time that took place the Trojan War.

In later centuries, the main event is the growth of Rome from a small town to a universal empire; the function of the Romans in history in general and, as far as we are concerned, is of paramount importance in the creation and definition of the very idea of law, from which the organization was not, at that time, distinguished.

The Roman Empire missed the transition to an industrial society, albeit they were close to it: they were using prefabrication and mass production. However, they failed to trigger an industrial revolution, probably due to lack of adequate energy sources as well as to the use of slave labour. The civil and military organization of the Empire has been a model for centuries, and still offers interesting insights: the NOTITIA DIGNITATUM, document dated between 395 and 420 AD and issued by the imperial chancery, can be considered as the first organization manual.

From the Roman culture we also derive the bases for cost management and engineering; the real profes-
sion of the ARCHITECTUS described by Vitruvius is not so much an architect as we understand it as a project manager and a description of operations by project can be found in the Commentaries DE BELLO GALLICO of C. JULIUS CAESAR.

In the period between the fall of the Roman Empire and the industrial revolution the organization evolves mainly as ecclesiastical organization, and as a state organization: evolves the canon law together with the major legal systems; many of the principles, concepts and rules of modern organizational science must be traced back to the great ecclesiastical organizers.

The need of the division and specialization of labour is a consequence of the industrial revolution, whose roots are from the tenth century: it becomes slowly a reality in the following centuries, exploding from the second half of eighteenth century. In addition, with the increase in the size of structures and the number of people employed in them, there is a need of complex hierarchical structures.

Max Weber (1864-1920) has identified three types of authority, the first based on tradition, the second connected to supernatural values, the third inspired by the rule of law and reason. The latter system, that Weber calls “bureaucracy”, according to him is the perfect form of organization: exercise of power based on impersonal rules and procedures.

The organization science has been developed in the twentieth century by several scholars, out of them Taylor, Gantt, Fayol, Mayo, the scholars of the Tavistock Institute, Galbraith and a lot of others.

2 Bureaucracy and level of work

The term “bureaucracy” has been widely used from Elliott Jaques and from other scholars. It is convenient to use the term “executive hierarchy”, since the word “bureaucracy” has assumed a pejorative meaning, in majority of languages.

The etymology of the word is hybrid, from the French “bureau” (office) together with the ancient Greek “κρατεω” (kratéo, have the power to).

The definition given by Jaques is: bureaucracy is a “hierarchically stratified managerial employment system, in which people are employed to work for a wage or salary; that is to say, stratified employment hierarchy with at least one manager, who in turn has a staff of employed subordinates (A General Theory of Bureaucracy, Gregg 1993, page 49)”

Bureaucratic systems, also named executive hierarchies, are therefore a secondary and dependent institutions.

Secondary since they cannot be established directly and autonomously, but must be set up by external authority, entrepreneurial, political or otherwise, that can be defined as primary or institutional authority.

Dependent in the sense that the continuity of their existence depends on the primary authority, on whose behalf it carries out its work, the aims of which are fixed by the primary authority.
A major difference between paid employment and self-employment, in fact, is that self-employment has the prerogative to decide, at least partially, its aims and targets.

An employment in said organizations is characterized by an assignment, whose retribution is a payment is proportional to the time (actual time or calendar). The employees assume only technical risks, namely any risk related to their capability as well as to their performances, without assuming any economic or financial risk (workload, payments, costs, profitability, etc.).

In addition to the basic wage or salary, they can receive production bonuses based on performance that do not modify the structural bond of an executive hierarchy. Premiums whose calculation is based on sales, profit and any other value different from performance are a different thing, more similar to remuneration of self-employed people.

There should be always a correspondence between people and jobs held: every vacancy occupied by one person, each person occupies only one vacancy. You can have the case of vacancies that are assigned on a temporary base by the holder of another job, but this should be exceptional and temporary solution.

In any other case where the same person is found to occupy more than one job there is mismatch between the real organization and the way in which it is represented.

3 Measuring the level of work: the time span of discretion

The starting point for measuring the level of work is the assertion that the level of maturity of a person, from a psychological point of view, corresponds to a temporal parameter. This is an old idea that we can find, albeit embryonic, in the Stoic philosophy. In our case, the idea consists in using time as a reference parameter for measuring the level of work and for comparing levels of work of different jobs, even in different executive hierarchies.

Being capable to measure the level of work, we shall have a better understanding about work and its real meaning in an executive hierarchy and then we shall increment our capacity to organise the work itself as well as to manage the people involved. According to lord Kelvin:

“I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of “science”, whatever the matter may be.” (Electrical Units of Measurement, 03/05/1883, Popular Lectures, Vol. I)

The first consideration is that each task has a target time, explicitly or implicitly assigned for to its completion, and that the more a person rises in the hierarchy, the more the time frame of the tasks assigned to him is characterized by long time intervals.

Jaques and others have suggested, and then demonstrated with studies lasted from 1950 to the present, that the level of a task can be measured in a direct and simple way according to the time schedule for
completion of the longer term tasks. Reference should be made to:

- first of all the Glacier Project (1950-65),
- the Brunei Project (1968),
- the studies on the organization of the British NHS after the Fulton report (1970),
- the research of Ivanov (2001-06) in United States and Latvia.

The basic assumptions are:

- Every concrete task that someone is required to do has a target completion time.
- The higher a person goes in an executive system, the longer is the time framework within which he or she works.
- A job’s size can be directly and simply measured by completion times targeted for the longest tasks that are required to be carried out in that role, namely, the time span of discretion.

If we consider a job in an executive hierarchy, there shall be a complex of tasks, subsequent or simultaneous, of different time span with a control system at fixed intervals or variables. In these tasks, there is always a prescribed content and a discretionary term; the discretionary terms must always be present, since if it is lacking you could replace human work with automated devices.

We then define “time span of discretion”

- the longest task assignments in a job with subsequent tasks with immediate control,
- the sequence of longer assignments to subsequent tasks with deferred control,
- the time allotted for the long between the long-term tasks, for jobs in concurrent tasks.

A short definition of the time span of discretion is “the length of time that a person can work, into the future, without direction, using their own discretionary judgment”

Time span of discretion do not coincide with the institutionalized control intervals and gives an idea of the frequency with which you should confer with your chief; we could demonstrate that it coincides too with the time necessary to make manifest a marginal inefficiency.

On the basis of said time span, you may define a set of managerial strata corresponding to different levels of capacity to work; each stratum can be divided into more levels or substrates, to take into account, in a detailed way the articulation of the capabilities and functions.

You have then a criterion to follow:

- Each job has a defined level of work in terms of time span of discretion: it must be occupied by a person whose current working capacity corresponds to the time span required.
- The hierarchical stratification must take into account the difference between two different hi-
Hierarchical levels in terms of time span of discretion, this should correspond to different managerial strata. The hierarchical levels with lower difference are fictitious levels and correspond mostly to intermediate levels of supervision.

The individual work capacity, in terms of the time span of discretion, grows regularly with age, it is not yet clear whether asymptotically or starting to decline after an age, that becomes older as much as the capacity is higher.

Jaques sets, by convention, the “nominal capacity” as the capacity for work at the age of 55 years; Since the capacity for work is a combination of psychological and physical factors (software and hardware), probably the decline at old age, if any, is due to causes purely physical. The actual pattern of the curve is then asymptotic.

The nominal or potential capacity depends on studies and cultural background, including family background, intelligence and willingness, knowledge and competency, psychology and other factors.

We believe that the original curves of Jaques should now be updated to take into account the increased life time. The picture below represents a set of potential capacity curve from the research Mike Jay’s Musings on Developmentalism (2004)
In a system of differential salaries, we define “equitable payment” or fair pay the salary that the employees statistically perceive as fair in relation to the duties actually carried out, without taking into consideration what they could or would play. The surveys have shown a direct relationship between time span of discretion and equitable payment.

This is true for jobs within a business organization, but also for military hierarchies and public administration, as shown in the charts below.
The table can be completed with further studies and research such as Rawbottom & Billis, Ivanov, Paterson, Castellion and others and can eventually be compared to the Italian case. Here below a table that compares the levels proposed by Jaques, Paterson and Castellion.

The time span of discretion can be longer than human life: a person whose time span capacity is longer than his life span can be defined a genius, he’s developing a more than lifetime work with the frustration of knowing that he will never see the completion of what he has started.
<table>
<thead>
<tr>
<th>Jaques</th>
<th>Paterson</th>
<th>Castellion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratum</td>
<td>Time span of discretion</td>
<td>Level of abstraction</td>
</tr>
<tr>
<td>I</td>
<td>Up to 3 months</td>
<td>Perceptual motor concrete</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>II</td>
<td>3 months to 1 year</td>
<td>Imaginal concrete</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>1 to 2 years</td>
<td>Imaginal scanning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>2 to 5 years</td>
<td>Conceptual modelling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>5 to 10 years</td>
<td>Intuitive theory</td>
</tr>
<tr>
<td>VI</td>
<td>10 to 20 years</td>
<td>Institution creating</td>
</tr>
<tr>
<td>VII</td>
<td>20 to 50 years</td>
<td>More than 50 years</td>
</tr>
<tr>
<td>VIII and more</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The last chart shows an application to the military organization

The time span of discretion is related to the "psychological level" of the person, therefore to the capacity to have a vision towards the future as well as the past, locally or globally. The same could be said for his cultural vision in general.

4 Equitable payment

The theory of the equitable payment is consequential to the above studies. It has not been widely applied due to the fact that both parties (unions and employers) have decided to rely on negotiation instead of relying on an objective criterion. The illusion of both parties has been that they could afford the better results through negotiation than they could have obtained through rationalisation. By this way, they have originated a market distortion with regards to the relationship between level of the work and salary.

“The time span of discretion coincides very closely with people's judgments about fair pay for the work involved. Thus the same time span will result in the same statement of fair pay regardless of the actual occupation or pay”\textsuperscript{iv}.

The level of the work pertaining to a specific role in any organization can be measured by the time span of discretion, that can be used also to compare the level of the work pertaining to roles in different orga-
nizations, as it has been described in the previous paragraph.

For each level and for each role can be defined an **equitable payment**, that is the pay statistically considered as equitable by people for the work they are actually doing (without considering neither the work they would like to do nor the work they feel to be able to do).

By this way, we define a concept of equity that is different from both legal and ethical definitions of equity. Probably we could use the term statistical equity, or maybe it would be better to speak about **felt fair payment** without involving any concept connected with equity.

The payment to be considered is the gross wage or salary, namely the amount before taxes. Different levels of taxation have nothing to do with equitable or fair payment.

According to the research of Jaques, the correlation coefficient with the job was 0.86 for time span and 0.79 for fair pay. Other research gave values from 0.85 to 0.90

The equitable payment can be calculated with an exponential formula:

\[ R_e = R_0 \exp \left( \frac{\lambda}{\lambda_0} \right) \]

- \( R_e \) = equitable payment
- \( \lambda \) = corresponding time span of discretion
- \( R_0 \) = equitable payment for a work whose time span of discretion is near to zero (minimum wage in the considered country)

The term \( \lambda_0 \) is a parameter depending to the general economic level of the country considered.

The actual values for \( R_e, R_0 \) and \( \lambda_0 \) are the result of a statistical investigation and data collection. According to the theory, if the above conditions are met, there should be no need to relate the payment to the performance since people should be enough motivated to give the best performance. However, the last point should be verified with reference to the updated situation of the labor market.
The curve shows the equitable payment relevant to three different countries. It is worthy to note that

- the curve under A is relevant to medium economic level country, the level of wages is higher and a higher differential is accepted,
- the curve under B is relevant to a lower economic level country, while
- the curve under C is relevant to a poor country, the level of wages is clearly lower and the differential is barely accepted.

To go into more detail, we could define as differential wage ratio the ratio of the equitable payment corresponding to the time span of discretion of 10 years (general manager of a big company), to the equitable payment corresponding to the time span of discretion of 1 day (unskilled labourer).

The real differential wage ratio shown in the above cases is 25 about for curve A, 11 for curve B and 6 for curve C, further research gave a result equal to 40 for an affluent society.

<table>
<thead>
<tr>
<th>Differential wage ratio in some real cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glacier project (UK)</td>
</tr>
<tr>
<td>1954</td>
</tr>
<tr>
<td>1955</td>
</tr>
<tr>
<td>1964</td>
</tr>
<tr>
<td>Brunei project</td>
</tr>
<tr>
<td>1968</td>
</tr>
</tbody>
</table>

According to further studies in the Glacier project, there is a correlation between the fair pay and the value of the resources under direct control, if both are calculated referring to a time span corresponding to the time span of discretion:

Fair pay = (resources) x (interest rate)

Apparently the fair pay is then more related to the potential losses that the worker can cause than to the actual value that he is creating.

Equitable payment is only one of several elements involved in the implementation of a coherent and effective reward system. However, the gross salary per year is the parameter that is taken into consideration when comparing different jobs or job opportunities, while the overall value of the payment package, that includes for pension funds, health insurance, life insurance, is barely understood by medium and low level people.

As a matter of fact, pay is not the only variable, any person reacts to a broader set of trading conditions, the reward system is composed by payment package, career opportunities, status and formal recognition, work environment and satisfaction, learning opportunities, health and safety.
An incentive system can have distortive effects, in all cases where individual interest does not correspond to the interest of the organization as a whole.

5 Status and its congruence

This point can be analysed on different point of view, socially and professionally.

Social status

Social stratification has been defined by Max Weber through a multidimensional approach that can be simplified in three dimension that are

- Economic situation, that includes for properties and income,
- Prestige, that is relevant to the respect given by others, and
- Power, namely the ability to achieve their goals against the opposition of other parties

In an executive hierarchy, the level of works affects all three dimensions. However, a person exists even outside their job, and can have a different status in church, professional associations, private clubs, politics and so on.

Social status, in a multidimensional sense, can be defined as a position in any of the different social scales ranking people in the society, such as economic status, social position both individual and familiar, prestige attached to the occupation, level of work, respect, etc.; “status congruency” means that all the social statuses of a person rank at the same level, if not “status discrepancy” occurs.

**Professional status**

Within the executive hierarchy, professional status is basically given by the level of the job, namely the level of work (W: time span of discretion) corresponding to the role in the organisation. This has to be congruent with the individual capacity (C) as well as to the payment (P), that we define as C- W-P equilibrium.

Unbalanced work situations will create problems, either operational or psychological, due to over-employment or to under-employment, that can be understood for the various possible cases, such as:

<table>
<thead>
<tr>
<th>C=W=P</th>
<th>Equilibrium</th>
<th>The worker is normally satisfied with his work and works efficiently</th>
</tr>
</thead>
<tbody>
<tr>
<td>C=W&gt;P</td>
<td>Capacity congruent with level of work, low payment</td>
<td>The worker normally feels frustrated, if he’s satisfied generally this is because of lower performance</td>
</tr>
<tr>
<td>C=W&lt;P</td>
<td>Capacity congruent with level of work, overpayment</td>
<td>Creates a general problem in the <em>morale</em> of the organization, the single worker can feel guilty and this can lower his performance due to high rate of errors</td>
</tr>
<tr>
<td>P&gt;W&gt;C</td>
<td>Level of work higher than capacity</td>
<td>Disorders due to stress</td>
</tr>
<tr>
<td>P=W&gt;C</td>
<td>Level of work higher than capacity plus underpayment</td>
<td>Disorders due to stress, neurosis, instability</td>
</tr>
<tr>
<td>W&gt;C&gt;P</td>
<td>Level of work higher than capacity</td>
<td>Can work on a temporary basis, in the long run causes organization problems and assumption of responsibilities beyond the actual powers</td>
</tr>
<tr>
<td>P&gt;C=W</td>
<td>Low level of work, fair payment or overpayment</td>
<td></td>
</tr>
</tbody>
</table>
Furthermore, there has to be a congruence between the nominal time span of discretion and the level of works expected in the future. A thorough analysis on the progression of the individual capacity compared to the level of work assigned to him should be performed in order to project both in future through a regression curve and verify the congruence.

6 Compatibility with social inequalities

We must understand why a high differential in equitable payment is normally accepted in highly developed societies, while it is badly considered in low income or poor countries. This bring the need to understand something more about the inequality in income distribution and to the general problem of the so called “social justice”.

We shall use as measure of the wealth the GNP per capita adapted to purchasing power (PPP) and the Gini coefficient as measure of the inequality: although we are aware that the Gini coefficient has some limits, we believe that it is still a method of measurement easy to manage and to understand.

In recent time, important studies on that matter have been made by Angus Maddison first (please refer to Maddison Project) and then by Branko Milanovic.

The purpose of Milanovic’s research was to measure “how close is measured inequality to the maximum inequality that can exist in a given society”, that he calls maximum feasible inequality. The first situation to be considered is the case of a pre-industrial, subsistence economy where all people but an extremely small minority live at subsistence level. Taking into consideration.

- $Y =$ total income,
- $n =$ number of people,
- $s =$ level of subsistence (at purchase power parity)
- $e =$ minority

The surplus over the level of subsistence shall be

$$S = Y - n (1 - e) s$$

Then the income of the minority

$$M = S / e$$

The level of subsistence is to be calculated in physiological terms, without any social consideration.

In theory, it should not have any variability. However, we must accept that some variability can be due to different climates or other environmental conditions.

If we calculate the mean income
\[ m = \frac{Y}{n} \]

And then its ratio to the income corresponding to the level of subsistence

\[ a = \frac{m}{s} \]

defines the coefficient of Gini, that actually corresponds to the inequality frontier, shall be

\[ G_0 = \frac{(a - 1)}{a} \]

We can define an inequality possibility frontier that is the locus of maximus possible Gini (G0) coefficients and then the inequality extraction ratio \( R = \frac{G}{G_0} \) that is the ratio of the real Gini coefficient to the maximum possible Gini. \( R \) gives an estimate of how close a society is to its inequality frontier.

A further consideration is given by the fact that, when the general level of the country increases, people will not accept anymore to live at subsistence level, then the physiological minimum becomes a social minimum \( S_0 \) (relative poverty line), that tend to increase with the mean income.

A more affluent society requires a higher social minimum.

We must consider that the definition of poverty is not limited to the inability to satisfy basic needs, but should take into consideration the capability to operate without shame in a society: this definition can be found in the works of several scholars throughout the centuries, the most recent one are Amartya Sen and Ravallion.

The social minimum \( S_0 \) can be defined as

\[ S_0 = s \, a^x \]

Where \( x \) is the elasticity
The elasticity\(^{\text{vi}}\) of the social minimum compared to the mean income\(^{\text{vii}}\) is a number between 0 and 1, that is to say that its increase is less than proportional to the increase of the mean income.

According to Chen and Ravaillon the elasticity of the official poverty line with respect to the mean income is 0.33.

However, taking into consideration that the socially accepted minimum (subjective poverty) is well above the poverty line, a more reasonable value of the elasticity, seems to in the range from 0.40 to 0.70 (Flik, van der Praag)

Milanovic has calculated a general expression that links the maximum feasible Gini, the average income and the elasticity of the minimum with respect to the average income.

\[ G = 1 - \frac{1}{a} ax \]

- If the elasticity \( b=1 \), it means that the social minimum increases as the average income, namely that to all members of the community has to be guaranteed the mean income. Gini is equal to zero.

- If the elasticity \( b=0 \), the social minimum is corresponding to the subsistence level, Gini can be close to 1

- If \( b=0.5 \), a reasonable value, the social minimum has an increase of 50% of the increase of the mean income. This is one among the definitions used for relative poverty level\(^{\text{viii}}\)

Useless to say, the real problem when trying calculations on real data is the correct identification of the purchase power parity coefficient.
As far as the relationship between equitable payment and social inequality is concerned, it has been understood that a high “general income” (that is can be identified with the arithmetic mean or with the median income) allows for higher “differential incomes”, that, as far as work income is concerned, can be identified with the wage differential ratio.

According to Jaques, the fundamentals of that are to be found in the relationship between fair pay and fair expenditure capacity, for a person whose potential capability of work be congruent with the work he's actually doing.

A similar relationship between the PPP pro capite and the maximum Gini has been found by Paolo Malanima in his historical research on the development of Italy.

7 Proposal for self-employed people, professionals and their certification

It's quite difficult to define something equivalent to the time span of discretion for self-employed people as well as for professionals, this is due to the lack of any statistic research about. However, the self-employed as well as professional works are related to time more or less in the same way as identified for executive hierarchy, with the difference that the relationship of the employee to the manager and to the second level manager should be replaced

- At first level, with the relationship with the client or, to be more precise, with the relationship to the referee in the client’s, to be considered approximately as the same level, like a coordinator
- At second level, with the relationship to the higher level manager that decides when assume a consultant and whom assume

Then we could probably define the time span of discretion for professionals at least in terms of stratum. A further research could define a criterion for equitable payment, at least for those professionals whose payment is based on time.

8 Conclusions

1. Time span of discretion is the focus of an extensive research conducted over a period of 50 years by Elliott Jaques and others. The concept allows understanding and measuring several elements related to the complexity of a task, complexity of a role and the capability of a person.

2. It is defined as “the length of time that a person can work, into the future, without direction, using their own discretionary judgment.”

3. Then the time span of a delegated task can be defined as the elapsed time between the task handing off and the completion of the task itself. Time span can be used to measure the complexity of a task: the shorter the time span, the more certain are its elements and its outcome, the longer the time span, the less certain are its elements and its outcome (the precise definition has more details).

4. The time span of discretion can be used as a guideline to create a system of ranks in order to divide
rank from role as well as to compare roles and then working levels and related payment in different organisations. This is quite normal in major organisations; reference can easily be made to the military structure.

5. Each person at a certain time of his life is able to work at a certain individual time span of discretion corresponding to his level of culture, experience, and professional capacity as well as of psychological maturity. The individual time span of discretion increases with the age, the time span corresponding to 55 years of age is defined “nominal time span of discretion”.

6. The use of this measuring method, besides allowing comparisons between roles in different organisations and dimensioning of the payment system, allows to compare the individual capacity to the job assigned as well as to make some assumption with regards to the potential capacity. The individual capacity should be congruent with the role and with the payment.

7. The differential payment that is considered equitable increases with the increasing of the general level of the economic system

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i Or “time span of discretionality”

ii PPA (potential progress assessment) index

iii The table is taken from Josephine Jordan, Classification of jobs into level of work (with some integration)

iv Quoted from Elliot Jaques – Taking Time Seriously in Evaluating Jobs – Harvard Business Review, September 1979 Y A correlation coefficient is a coefficient that illustrates a quantitative measure of some type of correlation and dependence, meaning statistical relationships between two or more random variables or observed data values.(from Wikipedia)

vi Elasticity can be defined correctly in term of differential equations. However a simplified definition is “the ratio of the percentage change in one variable to the percentage change in another variable, when the latter variable has a causal influence on the former”. The correct definition of elasticity of the function $y=f(x)$ in point $x$ is

e=\frac{dy}{dx}/x=\frac{y}{x}

vii Median income is the amount that divides the income distribution into two equal groups, half having income above that amount, and half having income below that amount. Mean income (average) is the amount obtained by dividing the total aggregate income of a group by the number of units in that group.

viii The relative poverty level is calculated as 50% or 33% of the mean income. According to other scholars, it should be 50% of the median income.
Cost Engineering and Compliance Pricing Analysis

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ABSTRACT

This paper aims to present a methodology for calculating and values for the variables that comprise the BDI (Budget Difference Income) as technical and very well justified, for it can't be defined by average not even has maximum percentage to be admitted. It has to be calculated in every work.

Objective

This paper aims to give readers material for consultation on the methodology to elaborate works budget.

Methodology

The method of budgeting for civil works so far adopted in our country (Brazil) has its origin in the English language and designed in the United States of America (USA), so some terms still retain their origin, for example, corresponds to the BDI initial term Budget Difference Income. Evidently this term in Brazil was totally misrepresented, however, the methodology of budgeting applied here is very simple. Thus, there was the need to generate its own methodology to Brazil. We must face the BDI in two ways, by a vision of engineering service provider and another by the contracting agency.

Value

It is necessary and very important to adopt the calculation methodology and values for the variables that comprise the BDI technical and very well justified way, in order to not suffer any reaction from the organs auditors external and internal.

Originality

The Engineering Schools in Brazil have always had a degree training aiming teaching of Engineering Techniques, but never bothered with a specialty in the professional field of budgeting in a construction, involving many variables that are implicit in the calculation of formation prices, particularly in calculating
the selling price. Therefore, this work contributes to Cost Engineering.

**Conclusion**

Cost Engineering is a Science, not an art, where each professional does whatever he wants. Unfortunately, in Brazil, it is being this way. Therefore, this work contributes to the spread of knowledge of Cost Engineering.

**Keyword:** Engineering – Costs – BDI – Compliance Pricing – Price

**Cost Engineering and Compliance Pricing Analysis**

Economic globalization transforms the market where every day new participants appear, as partners, customers or competitors, with new concepts, methods, technologies and products. The processes are increasingly dynamic and Concurrent Engineering gradually replaces the Serial Engineering, reflected in costs from the new contractual arrangements, new models and new concessions, shallower organizational structures as well as the formation of consortia and spraying companies.

The Measuring of Knowledge Age acquires new forms, for the new dynamic provided by the Information Technology and Communications, but the information architecture remains.

The market is rapidly changing, increasingly complex, requiring companies to reduce prices, increase quality and accelerate operations and innovate constantly. The corporate response undergoes several transformations, the number of hierarchical levels, lateral expansion of responsibilities with professional performing tasks and functions and not constant revision of strategies, tactics and operational processes. The development of Information and Communications Technologies (ICT) provides a very important link between business strategy, business process and product engineering. The New Science of Knowledge recognizes that knowledge is constructed, maintained and from information developed through processes of communication and dissemination of information, adding the personal experiences of experts, according to the equations below:

\[
\text{Information} = \text{Data} + \text{Context}
\]

\[
\text{Knowledge} = \text{Information} + \text{Experience}
\]

Regarding Current Cost Engineering, we have that the selling price of a service engineering is comprised of the following items:

\[
\text{SALE PRICE} = \text{LABOR} + \text{MATERIALS} + \text{EQUIPMENTS} + \text{LOCAL GOVERNMENT} + \text{BDI}
\]

As for Labor, which is an item of high cost and strategic importance, we have to consider than the remuneration of professionals, and other requirements of the law, among other items, we cite the following:

Payroll;
Additional charges (transport, food, Rules of Procedure of Ministry of Labour, life insurance and market) and;

Accommodation, transfer, training and profit sharing.

Currently, these costs to construction workers reach up to 300% of the basic pay of the professional.

As for materials, the challenge of the service provider is greater in view of the high risk involved, due to the determination of the value of the input in the proposal and the natural oscillation of the market until their actual acquisition.

By quoting particular material at the time of preparing the budget, the proposals involve economic risks that are not reduced by the sample size, however, require careful handling to expunge distortions and adopt the most appropriate price. Thus reducing the potential needs of the application for renewal of contract claims to its economic-financial balance, in view of the time limit for its acquisition.

As for equipment, we have to analyze whether they are themselves or others.

If third party, we must admit the same situation for material commented. When you own will fit the company to assess the huge investment required and the need to continually contracting services where these are properly applied. In construction equipment cost is not usually a significant portion.

The cost of Local Administration of the contract is significant mainly by hand factor work and everything that was previously mentioned. Of course raising the selling price shall appear in the Bill of Quantities. It involves, among other things, engineers, master work, office staff, storekeeper and property security. Not forgetting support vehicles, capital assets, water bills, electricity and telephone services and consumables.

While the BDI – Budget Difference Income, when applied to the Construction, has calculation methodology that involves the profit margin of the companies, taxes on income and variables defined in percentage, such as the Central Administration, the Insurance, the Contractual and Financial Cost guarantee. The contractor must also consider the risk margin of error.

\[
\text{Indirect Costs} = \text{Cost} + \text{Insurance} + \text{Financial} + \text{Central Administration} + \text{Contract Guarantee} + \text{Error Margin}
\]

The Central Administration always uptrends due to the need to invest in new technologies, techniques and exploring innovative business.

\[
\text{BDI} = \text{Profit} + \text{Indirect Costs}
\]

Knowing that BDI is inversely proportional to the value of the contract and has less relation to the type of project, its specific conditions, the period of the work, as well as several intrinsic factors of each work, has no sense to define an average BDI, even sectorial and yes, calculate the BDI contract by contract, in
case the service provider.

The contractor will calculate the BDI Reference (or medium for companies who regularly participate in their bids) for each value range of contract.

The Central Administration, in the case of the Contractor, shall be adopted after the establishment of research with the executing companies.

<table>
<thead>
<tr>
<th>Average BDI Reference - Composition(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUSTO DIRETO</td>
</tr>
<tr>
<td>CUSTO INDIRETO</td>
</tr>
<tr>
<td>LUCRO</td>
</tr>
<tr>
<td>CUSTO DIRETO</td>
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<tr>
<td>CUSTO INDIRETO</td>
</tr>
<tr>
<td>LUCRO</td>
</tr>
</tbody>
</table>

The Price of a Compliance service is to ensure the application of the parties involved, including relevant Brazilian tax legislation, good technique of Cost Engineering and effective implementation of the project scope.

The participation of the IBEC in the Program PROSUB (Submarine Development Program with Nuclear Propulsion) comprising the correct application of these theories, techniques and practices, to run the Cost Management, is engaging, thought-provoking and challenging for the whole team, because besides the great knowledge in Engineering Costs it requires all participants should rely on experienced professionals in budget execution and monitoring of works in different disciplines as well as strong familiarity with management of solid enterprises, ensuring compliance services prices listed at Work Breakdown Structure presented in the proposal of the contractors, of point of view not only of the applicable law, but also in view of the regulatory authorities and the contractors concerned. As well as ensuring the needs of the performing organization.

The enormous difficulty of Construction requires from the Cost Management team constant technical improvement and deeper study of cases occurring in the contract staff.
Measuring the Impact of Rework on Project Cost and Schedule
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ABSTRACT

Purpose of this paper

Rework can have a negative impact on the performance of the construction industry, therefore, there is a need to study this issue in order to minimize or eliminate its impact on construction project cost and time. The aim of this paper is to measure the impact of rework on cost and schedule of wells and main agricultural water lines project in the Gaza Strip. Four issues were investigates: occurrences of rework and their causes, then determined the responsible party for rework and calculated the impact of rework on project cost and time.

Methodology

A qualitative approach was adopted in this study; wells and main agricultural water lines project was used as a case study. Data were collected through site visits, interview with project parties and review project documents.

Findings

Results revealed that most of the rework cost, which was caused by the contractor, occurred because contractor was technically unqualified, lack of quality control, using materials not according to specifications and using unskilled workers. Findings indicated that insufficient pre-planning of the project from owner (Ministry of Agriculture) has led to reworks. The results indicated that reworks increased project cost by 9.5\% of original project cost. Rework increased the overall project delay by 76.7\%, and the percentage of rework time was 31.4\% of project duration.

Research limitations

This study is limited by its methodology as it is difficult to generalize the results. However, the results and recommendation of this case study can be used when a similar issue arises in a future project.
Practical implications

It is recommended to document rework events in projects, and to establish a control system for minimizing rework. This issue will assist project managers to identify the best methods to improve the performance of contractors to minimize rework. Consultant needs to assign a qualified supervisory team with suitable experience in order to control rework. Training programs for employee regarding causes of rework and measures to eliminate rework is recommended.

Originality/value of this paper

This study refers to a practical mechanism for calculating rework cost. In addition it highlights the seriousness of rework problems, it draws projects parties' attention to rework causes and impact on project performance.

Conclusions

It was observed that reworks were not documented; however it was documented as new works. Project parties have not calculated reworked cost, although they didn't deny it. Low contract value and low profit margin encourage contractor to look for more profit by using materials and equipment with less cost and less quality. There was clear relationship between labors type and amount of rework, where there was minimum rework where its labors were skilled workers; there was high rework where labors were unskilled.

Keywords: Rework, cost, time, wells construction

INTRODUCTION

Rework is a major contributor to time wastage and schedule overruns which eventually impact on cost, resources and quality (Love and Edwards, 2004). Cooper (1993) stated that rework emerges as overtime, the additional hiring of resources such as labour and plant workers, schedule slippage, and reductions in project scope and quality. The adverse consequences of rework include reduced profit, loss of market share, damaged reputation, increased turnover of management and workforce, lower productivity, higher costs, and finally, costly litigation between participants over responsibility for overruns and delays (Williams and Howick, 2000). Rework may happen because of the lack of quality control, insufficient maintenance, using unskilled workers and inadequate tools, etc.

Josephson et al., (2002) defined rework as “unnecessary effort of correcting construction errors”. This definition has been modified by Love (2002a) as: “unnecessary effort of re-doing a process or activity that was incorrectly implemented the first time”. Love and Edward (2004) redefined previous definition as: "non-required effort of re-doing a process or activity that was faulty executed at the first time". This agreed with Hwang et al., (2009) point view about rework where work must be redone because it was not following requirements. The objective of this paper is to study the impact of rework on schedule and cost of constructing wells and main agricultural lines project in the Gaza Strip.
LITERATURE REVIEW

Reworks and wastages are known as non-value adding symptoms that affect productivity and performance in construction projects (Alwi et al., 2002). Construction management literature offers several interpretations of rework, which differ in terms of verbal description, scope, and measurement. There are various interpretations and definitions of rework. Terms include: “quality deviations” (Burati et al., 1992), “nonconformance” (Abdul-Rahman, 1995), “defects” (Hammarlund and Josephson, 1999) and “quality failures” (Barber et al., 2000). Rework can be described as unneeded effort of redoing an activity or operation that was enforced in a wrong way from the beginning (Love and lie, 2000).

Construction industry is faced with significant problems of high cost of project delivery, bad financial performance and inability to deliver value to customers on time. As a result, the industry has been criticized extensively for poor performance and inefficient productivity (Palaneeswaran, 2006). Rework is a serious problem in the construction industry and has a negative impact on performance and productivity (Enshassi et al., 2009a; Enshassi et al., 2009b; Enshassi et al., 2007; Love et al., 2010, Simpeh, 2012). Every construction project is unique and unpredictable so occurring of rework is unavoidable (Alwiet al., 2001). Quality management principles and tools are not strongly embedded in conventional construction management practice. As a result, rework is accepted as an inevitable feature of the construction process (Alwi et al, 1999).

Rework is expected to occur in all construction projects. Love et al. (1999a) have developed a model to indicate factors that could influence rework. The major elements or items that have to be regarded in a sub-system of technical/operational are: operating environment, contractual method, level of technology, and technical support. These items determine the issues that are related to quality such as enhancement of the process, partnering or strategic alignment, and realization of customer needs. The main factors of human resource subsystem of a system are: skill availability, manpower, procedures of communication, and employee morale. These elements influence skill level, training needs, motivation of employee, and the process of making decisions in construction system and project organization (Love et al., 1999a). According to Love and Edwards (2004a), the root causes of rework can be categorized into three different factors: client-related; design-related and contractor-related factors, including site management and subcontractor factors.

Zhang (2009) reported that additional costs due to rework have a considerable adverse impact on project performance. Wasfy (2010) indicated that rework increased the cost of different work categories of residential-commercial tower between 2% to 30%. Rework caused delays in the different work categories resulting in the increase of their original durations from 10% to 77%. Additionally, rework caused clients and contractors dissatisfaction. Oyewobi et al., (2011) revealed that finishes have a higher contribution to rework costs than any other elements of building projects. Meshksarr (2012) revealed that, reworks influenced cost of project by 1.85% and 2.1%. Regardless of where above research done whether in developed countries as the United States, England, Hong Kong and Australia or in developing countries as Indonesia, South Africa, Saudi Arabia and Nigeria, the direct rework cost ranges between (2.5%- 26%). It must be taken into account that as a result of differences in definitions, scope, data collection methods used, and whether rework is calculated as a proportion of project or contract value, these numbers are not fully comparable. They do give an idea of the scale of rework (Love and Sohal, 2003). Love (2002d)
stressed that there is a lack of uniformity in the way in which rework cost data have been collected because of various interpretations as to what constitutes rework.

METHODOLOGY

A qualitative approach was adopted in this study; wells and main agricultural water lines project was used as a case study. Data were collected through site visits, interview with project parties and review project documents. This project was selected based on the agreement of project manager to cooperate in this study. Four issues were investigated, occurrence of rework and their causes, then calculated its impact of rework on cost and time, and determined the responsible party of reworks. Researchers looked at project documents and reports, made visits to the project site and made several interviews with project parties (owner, beneficiaries’ representatives, contractors and consultants). All reworks events, their main causes and their cost and time were recorded. Methodology which was undertaken in this research depended on formulas of rework delay and rework cost, which were reported in previous studies in addition to formulas, which were derived or modified to suit this study objectives.

Calculating rework duration and delay

Rework duration are tracked from the point where rework is identified since that time when rework is completed and the activity has returned to the condition or stated it originally (Fayek et al., 2003). The duration of rework includes the length of the standby/relocation time once rework is identified, the time required to carry out the rework, and the time required to gear up to carry on with the original scope of the activity. The sequences of events that constitute rework are shown in Figure 1.

![Figure 1: Components of Rework (Source: Fayek et al., 2003)](image)

In the case of a rework event occurring for a non-critical activity, which is the simplest case, the activity float can be used to absorb the delay caused by rework. This method will be happen if the time required for rework is shorter than the total activity float. Undesired effects may occur when a critical activity requires rework. A general expression of the extension of the total project can thus be calculated according to Said (2009) as follows:

Project Extension (>0, or 0 if negative) =

\[
\text{(New Activity Duration – Original Activity Duration) – Activity Total Float}
\]

From Said, (2009) rework delay equation can be derived as:

\[
\text{DoR(>0, or 0 if negative)} = AD_{\text{new}} - AD_o - TAF
\]
Where:
DoR: Rework delay = Project Extension because of rework (>0, or 0 if negative)
AD\text{new}: New activity duration after rework
AD\text{o}: Original activity duration
TAF : Activity total float

For example if activity A duration was 5 days with total float 2 days, rework duration 3 days. The delay of project because of rework (Rework delay) can be calculated according to equation 2 as:

\[ AD\text{new} = 5 + 3 = 8 \text{days} \]
\[ \text{DoR= (}>0, \text{or 0 if negative})= 8 - 5 - 2 = 1 \text{ day} \]

Calculating rework cost

According to (COAA 2001)

\[ \% \text{ Field Rework} = \frac{\text{Total cost of rework performed}}{\text{Total construction phase cost}} \] (3)

\[ \text{Total cost of rework} = D_{r} + ID_{r} \] (4)

\[ D_{r}: \text{Total direct field cost of rework} \]

\[ D_{r} = \sum_{1}^{n} l_{ri} + e_{ri} + m_{ri} + s_{ri} + v_{ri} \] (5)

\[ l_{r}: \text{Direct field labor and supervision cost of rework} \]
\[ e_{r}: \text{Direct equipment cost of rework} \]
\[ m_{r}: \text{Material cost of rework} \]
\[ s_{r}: \text{Subcontract cost of rework} \]
\[ v_{r}: \text{Vendor's and supplier's cost of rework} \]
\[ i: \text{Rework event} \]
\[ n: \text{Number of rework event} \]
\[ D_{r}: \text{Direct field construction phase cost} \]
\[ I: \text{Indirect field construction phase cost} \]
\[ ID_{r}: \text{Total Indirect field cost of rework} \]

\[ ID_{r} = D_{r} \times l/D_{t} \] (6)

Fayek et al., (2003) ignored delay cost of rework, when project has been delayed, this delay has financial consequences such as extending insurance and guarantees, delay penalties, supervision fees and head office cost. As reported by Said, (2009) when rework effect critical path of project, it will be responsible on project extension or delay which is produced because of that effect. So rework delay cost can be con-
cluded as in equation 6.

\[ DE_r = \frac{\text{DoR}}{\text{Project delay}} \times \text{cost of delay} \]  

(7)

Where

\( DE_r \): Rework delay cost

\( \text{DoR} \): Rework delay can be calculated from equation 2

By adding equation 7 to equation 8,

\[ \text{Total cost of rework} = D_r + ID_r + DE_r \]  

(8)

Structure of case study

The structure of case study can be summarized as follows:

Part one: This part included: brief project description, brief description of project manpower which included types of workers (skilled, semi-skilled or non-skilled), number of workers, engineers and supervision, project tools and equipment, project main characteristics and data collecting method in this case study.

Part two: This part included seven components which were summarized in Table 2, these are:

First column: Rework description, a brief description of rework event.

Second column: Main causes of reworks.

Third column: Direct rework cost, this cost was calculated according to equation 5.

Fourth column: Indirect rework cost, this cost was calculated according to equation 6.

Fifth column: Rework duration.

Sixth column: Rework delay, this time was calculated according to equation 2.

Seventh column: Showed the responsible party of rework.

Part three: In this part the total rework cost was calculated according to equation 8. For each rework event, then the total rework cost, duration and delay in the entire project was calculated. Then the percentage of rework cost and rework delay were calculated according to COAA (2001) equations as:

\[ \text{Percentage of rework cost} = \frac{\text{Total rework cost}}{\text{Total Project cost}} \times 100 \]  

(9)
Percentage of rework delay = \( \frac{\text{Total rework delay}}{\text{Total Project delay}} \times 100 \)  

Percentage of rework time = \( \frac{\text{Total rework time}}{\text{Total Project duration}} \times 100 \)

**RESULTS**

This case illustrates an infrastructure project in the Gaza Strip. This project consisted of two main components. The first one is to establish three agricultural wells each one with capacity range from 50 M\(^3\)/hour to 100 M\(^3\)/hour with cost about 50,000 U.S. dollars for each one. The second components contained 50 km 110 mm water pipes and 30 km 63 mm water pipes. All 110 mm pipes were buried under ground more than 80 cm. In view of the workforce in this project, there were two main workmanship groups; the first consisted of 15 workers and technicians with expertise in the installation of irrigation systems. The second group consisted of 12 workers and technicians working in the field of drilling and installation wells, and they had little experience in this field.

Contractor had supervision team which consisted of a project manager with experience of 20 years, site engineer with 10 years of experience and a foreman with 25 years. It should be noted that this supervision crew had experience in the field of irrigation lines more than in the field of drilling wells. Consultant team and donor team consisted of a site engineer with eight years of experience, electro-mechanic engineer with seven years’ experience in well’s construction. Owner representative (Ministry of Agriculture and farmers) had limited role in the project. Ministry of Agriculture and farmers were responsible to provide information about the soil and wells such as (water level, types of soil, and nature of underground water). It should be noted that the information which was provided by them were limited.

Researchers looked at project documents and reports and visited the project and made a number of interviews with the director of the project, owner, beneficiary representatives, contractor and the consultant. A number of rework cases were observed. Rework was recorded for this study in terms of its main causes, its impact on project cost and time, which party took the responsibility of that rework. Table 1 summarizes the characteristics of the project of the case study, and Table 2 summarizes the occurred reworks in the case study.
### Table 1: Characteristics of wells and water lines project

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project name</td>
<td>Constructing wells and main agricultural water lines</td>
</tr>
<tr>
<td>Project Location</td>
<td>North Gaza Strip (Jabaila and Beit-Hanoun)</td>
</tr>
<tr>
<td>Donor</td>
<td>Arab Monetary Fund (AMF) by Global Mercy</td>
</tr>
<tr>
<td>Owner</td>
<td>Ministry of agricultural and farmers</td>
</tr>
<tr>
<td>Designer</td>
<td>Ministry of agricultural and Global Mercy projects department</td>
</tr>
<tr>
<td>Consultant</td>
<td>Global Mercy projects department</td>
</tr>
<tr>
<td>Contractor</td>
<td>Second class contractor</td>
</tr>
<tr>
<td>Type of contract</td>
<td>Traditional contract (Unit price)</td>
</tr>
<tr>
<td>Planned budget</td>
<td>300,000 U.S. dollars.</td>
</tr>
<tr>
<td>Contract Value</td>
<td>280,000 U.S. dollars.</td>
</tr>
<tr>
<td>Actual project cost</td>
<td>283,000 U.S. dollars.</td>
</tr>
<tr>
<td>Cost overrun</td>
<td>3,000 U.S. dollars.</td>
</tr>
<tr>
<td>Planned duration</td>
<td>5 month</td>
</tr>
<tr>
<td>Actual duration</td>
<td>7 month</td>
</tr>
<tr>
<td>Time overrun</td>
<td>2 months</td>
</tr>
<tr>
<td>Extensional duration</td>
<td>1 months (agreed extension between project parties)</td>
</tr>
<tr>
<td>Unsatisfied delay</td>
<td>1 month, the contractor carried all delay consequences</td>
</tr>
<tr>
<td>Overhead cost</td>
<td>145 U.S. $ / day (0.11 of project cost)</td>
</tr>
<tr>
<td>Delay penalties</td>
<td>150 U.S. $ / day</td>
</tr>
<tr>
<td>#</td>
<td>Rework description</td>
</tr>
<tr>
<td>----</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 1  | Rework of resupplying pipes, because first supplied amount failed in material test. The results appeared after two weeks. | - Inadequate coordination & integration between contractor, laboratory and supplier.  
- Personnel attitude  
- Pipes materials non-compliance with specification  
- Pre-fabricated materials not suitable for project requirement  
- Adulterated Materials from supplier  
- Late and invalidity of needed tests | 700 $                  | 2,200 $             | 17 days         | 10 days           | Contractor       |
| 2  | Rework of Re-drilled well No. 1 because of failing the well driller in the well and suspended in the bottom of the well, noted that the depth of drilling 92 meters in diameter 18 inches. | - Poor quality system  
- Contractor unqualified technically in wells field  
- Constructability problems  
- Acts of God: It was bad luck where rarely driller suspended  
- An insufficient skill level of labors.  
- Lack of safety commitment | 5,400 $                | 3,200 $             | 21 days         | 14 day            | Contractor       |
| 3  | Rework in number of water connection and pipe lines, because of poor workmanship. | - Poor workmanship  
- Ineffective management and decision-making from contractor and supervisor  
- Lack of audit and control supervision  
- Inadequate pre-project planning from owner and consultant  
- Social changes, where farmers sometimes affected negatively. | 200 $                   | 1,200 $            | 7 days           | 3 days            | Contractor       |
| 4  | Rework in scandium pipes, Quartz gravel and resupplying number of mechanical materials (pumps, filters) For wells. Bacausa of non-compliance with specification. | - Poor quality system from contractor  
- Ineffective management and decision-making from contractor  
- Adulterated Materials  
- Materials Non-compliance with specification  
- Inadequate supervision  
- Invalidity of needed tests  
- Competitive pressure/low contract value, the contractor wanted to increase his profit  
- Inadequate local education (supervisor- craftsman -technical) that didn’t have work experience. | 1,600 $                | 3,500 $             | 21 days         | 19 days           | Contractor       |
Table 3: Total direct and indirect rework cost and rework delay

<table>
<thead>
<tr>
<th>Col.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rework (Described in Table 2)</td>
<td>Rework material, equipment's &amp; supplying cost US($)</td>
<td>Rework labor cost US($)</td>
<td>Direct rework cost US($) (col.1+col.2)</td>
<td>Indirect rework cost US($) (equ. 6)</td>
<td>Rework time days</td>
<td>Rework delay days (equ. 2)</td>
<td>Rework delay cost US($) (col.6 x delay daily cost)</td>
<td>Rework total cost US($) (Col.3+4+7)</td>
</tr>
<tr>
<td>1</td>
<td>700</td>
<td>2,200</td>
<td>2,900</td>
<td>319</td>
<td>17</td>
<td>10</td>
<td>1,500</td>
<td>4,719</td>
</tr>
<tr>
<td>2</td>
<td>5,400</td>
<td>3,200</td>
<td>8,600</td>
<td>948</td>
<td>21</td>
<td>14</td>
<td>2,100</td>
<td>11,868</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>1,200</td>
<td>1,400</td>
<td>154</td>
<td>7</td>
<td>3</td>
<td>450</td>
<td>2,004</td>
</tr>
<tr>
<td>4</td>
<td>1,600</td>
<td>3,500</td>
<td>5,100</td>
<td>501</td>
<td>21</td>
<td>19</td>
<td>2,850</td>
<td>8,511</td>
</tr>
<tr>
<td>Sum</td>
<td>7,900</td>
<td>10,100</td>
<td>18,000</td>
<td>1,980</td>
<td>66</td>
<td>46</td>
<td>6,900</td>
<td>20,880</td>
</tr>
</tbody>
</table>

* Contractor was relieved from delay penalties but he earned delay overhead which was 150 US $ / day.
According to equations 9, 10, and 11 respectively

\[
\text{Percentage of rework cost} = \frac{\text{Total rework cost}}{\text{Total Project cost}} \times 100\% = \frac{26,880}{283,000} = 9.5\%
\]

\[
\text{Percentage of rework delay} = \frac{\text{Total rework delay}}{\text{Total Project delay}} \times 100\% = \frac{46}{90} = 76.7\%
\]

\[
\text{Percentage of rework time} = \frac{\text{Total rework time}}{\text{Total Project duration}} \times 100\% = \frac{66}{210} = 31.4\%
\]

Table 2 illustrates rework description and their causes. Most of rework cost was caused by contractor, because he was technically unqualified, had a poor-quality system, an insufficient skill level, especially in wells construction. The contractor wanted to increase his profit, so he tried to use cheaper material, which was noncompliance with specifications. Insufficient pre-planning of the project from the owner (Ministry of Agriculture) has led to rework. This result agreed with Meshksarr (2012), Gündüz et al (2013), and Alavifar and Motamedi (2014) who indicated that most severe causes of delay are rework due to errors during construction. The contractor trusted vendor certificates and checks, however upon completion of the examination the pipes’ samples failed to pass specifications tests which contributed to rework

Labors skills were not sufficient in the beginning of the project; they didn’t have experience in construction wells’ sector. Lack of safety commitment, poor management, and low contract value has led to rework in this case study. By comparing the results of this study with Love et al., (2010) study who tried to determine rework costs in civil infrastructure, they noted that from 115 civil infrastructure projects surveyed, mean rework costs were lower than the previously reported mean rework costs for building construction projects. The results that influence direct rework costs on cost growth for civil infrastructure projects were also considerably less than in building construction: 12% compared to 26% respectively, more than half of what was reported in building construction.

Results from Table 3 indicated that the percentage of rework cost was 9.5% of actual project cost, the percentage of rework delay was 76.7% of overall project delay time, and the percentage of rework time was 31.4% of project duration. Love and Song (2013) concluded that projects with a contract value less than 1$million had higher rework probabilities than that more than 15 million. Larger projects may be better managed, and longer completion times provide an opportunity to make adjustments to facilitate cost control.

CONCLUSION

Results revealed that rework increased the cost of the project by 9.5% and increase of the original durations by 76.7%. It was observed that reworks were not documented; however reworks were documented as new works. Project parties have not calculated reworked cost, although they didn’t deny it. It is worth mentioned that burden of rework affected all project parties, although most of it was carried out by
one party who was the responsible for its causes. Low contract value and low profit margin encouraged contractor to look for more profit by using materials and equipment with less cost and less quality. There was clear relationship between labors type and amount of rework, where there was minimum rework where its labors were skilled workers; there was high rework where labors were unskilled.

It was noted that most of manpower in the project were temporary workers, so the contractor was not interested in training them. On the other side, workers didn't feel loyal to the company because of lack of job security that may increase the percentage of rework in the project. This case study indicated that, there is a very strong relationship between the technical and financial qualifications and experiences of construction companies, and the amount of rework. Ineffective management and decision-making, personnel attitude (personnel issues), absence of job security can lead to quality failures, hence rework. It is recommended to document rework events in projects, and to establish a control system for minimizing rework. This issue will assist project managers to identify the best methods for improving the performance of contractors and to minimize rework. Consultant needs to assign a qualified with suitable experience supervisory team in order to control rework. Training programs for employee regarding causes of rework and measures to eliminate rework is recommended.

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Last Planner System - from theory to implementation

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ABSTRACT

Purpose of this paper

The purpose of this paper is to evaluate the efficiency of the Last Planner System (LPS) of construction project scheduling through a literature review of published case study reports.

Design/methodology/approach

The methodology used was a critical literature analysis on LPS case studies reports. This approach was chosen in order to consider case projects from different locations around the world; predominantly publications from the year 2000 to 2015 were examined. Several online platforms for academic papers were used in the study, and a systematic data processing was conducted in order to achieve statistically significant comparisons and observations.

Findings and value

The Last Planner System is new in the construction business, but there is already a good amount of reported case studies. Through the literature review it was found that there are a number of obstacles in the implementation of Last Planner System particularly in relation to matching the theory with practice. However, there is a general consensus in all the case studies examined, on the benefits of adopting LPS. The relation between the perceived benefits and perceived obstacles were analysed.

Research limitations/implications

The main limitation faced were the paucity of information on critical aspects of the implementation of LPS in Construction Projects. The study was based upon 24 different case study projects, and lack of robust and explicit information, such as completion time and cost, was a recurrent problem in the study.
Practical implications

This work aims to provoke a discussion on the Last Planner System and focuses on its implementation and challenges. It also seeks to establish the state-of-art practise of LPS in the construction industry. This information could potentially be useful for researchers and industry practitioners.

Originality/value of paper

The originality of this study is its investigative focus on the LPS technique over a 15-year period. Therefore, it aims to provide a general overview of the current practice of LPS in the industry.

Conclusions: This study identifies and highlights the obstacles in the implementation of LPS in construction projects, and assesses the potentials of LPS based on published case study reports. All the case studies attest to improved efficiency levels in the project completion time and enhanced inclusivity and bonding of the project team, when LPS is used in managing projects.

Keywords: Case Studies, Construction Management, Last Planner System, Project Completion time, Project Planning

1 INTRODUCTION

The Last planner System (LPS) technique has proven to be a valuable approach to scheduling in construction projects. Over the last two decades, there has been increased interest in the LPS technique (Ballard, 2000). The LPS technique stems from the “lean thinking” philosophy that emerged from the Japanese Industry in the early 1990’s. The LPS approach is however tailored to the application of “lean thinking” in construction project scheduling. The ‘last planner’ is the person with the expertise, or specific knowledge of how to actually produce the output that is required, by the specific project task. It gives the name to the System due to the great importance that the ‘last planner’ has on the Last Planner System (Pasquire, Zimina, 2012). The LPS requires the ‘last planner’ to decompose larger tasks into specific work assignments that can be given to individual construction operatives or teams, to complete in a relatively small time window. The assignment concept places emphasis on the actual work to be done and its attendant processes rather than creating a further plan that simply recognises desired outcomes (Ballard, 2000).

The purpose of this paper is to evaluate the efficiency of the LPS technique in construction project scheduling through a literature review. This research method provided the better means of appraising the LPS technique, given the scant availability of relevant data, and limited documentation of vital project information. The research was conducted in two parts: at first, a broad overview of the LPS theory, which resulted in the descriptive review below. Secondly, a meticulous analysis on LPS application through case studies, which resulted in the findings of this paper.

The Last Planner theory

Ballard introduced the Last Planner System in 1993 (Grenho, 2009) based on studies on how to improve assignments in weekly work plans, and how to control the work flow of design and construction projects.
The System is a philosophy and a set of rules and procedures, together with tools to guide the implementation process (Pasquire, Zimina, 2012). Traditional project management methods propose that a master plan informs what should be done. These objectives are transposed to lower level planning steps referred to as the lookahead schedule, and later, to weekly work plans (Ballard, 2000).

According to Ballard (2000), the lookahead schedule involves (i) identifying and listing the assignments that can be completed in the next work period, (ii) consulting with production experts to establish that each assignment can be feasibly completed within the identified time period and requisition of material and equipment for each task in order to proceed in the assigned week, (iii) identify any planned assignment that cannot be completed and adjusted in the look-ahead as required, and (iv) generate a list of activities to be completed prior to the issuing of assignments. In general, the lookahead schedules are already a usual practice in the production planning, but when allied to the correlation of ‘should’ with ‘can’, it acquires a new role in project planning. The Lookahead works as a prediction of the probable assignments for the next 3 to 12 weeks, depending on the project, and its impacts reverberate further when applied inside the Last Planner System.

Weekly work plans, on the other hand, are produced from look-ahead plans. They identify and sequence exactly what work should be done on each day to complete identified assignment. The last step in this sequence involves translating the objectives into assignments. This translation is implemented by the person or group who holds the last planner position. Howell and Ballard’s (2000) studies revealed that the absence of a critical analysis is the root cause of a high non-compliance rate. Traditionally, what should be done is automatically converted into assignments, not considering the possibility of existing constraints. The Last Planner System proposes that the last planner is responsible for transitioning the variable ‘can’ into ‘should’, and only then can he determine which assignments will be solved. In this aspect, this is one of the greatest contributions that Last Planner System in construction project planning and execution, and it can be visualized in the Figure 1, a scheme adapted from the proposed by Ballard (2000). Prior to establishing what will be done, the last planner must investigate if all the constraints to a specific work are removed. If not, this work is not an assignment at that specific week, and it must be postponed to coming ones.

Figure 1 The Last Planner System scheme
According to Mossman (2013), the Last Planner System (LPS) is about recognising the complex human relations that exists in a construction site, and work towards improving it, instead of supressing it. With this, problematic tasks are identified before they turn critical. The difference between the traditional method and Last Planner System becomes clearer when the Percent Plan Complete (PPC) of weekly plans are compared. PPC is a tool used to measure the non-compliance rate, being simply the completed assignments divided by the planned assignments (Koskela et al, 2010). It indicates that, in traditional methods, the low PPC percentage decreases the reliability of the plan that directs the work, causing its abandonment. Therefore, the PPC ratings of traditional project planning methods are usually lower then constructions projects that applied the Last Planner System technique.

Besides the improvement in PPC of projects scheduled, using the LPS approach, the system has a dynamic and feedback loop that facilitates workflow and process improvement as programme progresses. The improvements in efficiency are bottom-up in nature, and work on a “pull” principle which enhances the productivity function of tasks and work programmes. Tasks tend to be only progressed when they are ready to be progressed (Isatto et al, 2010). This removes waste and increases efficiency. In general, construction times tend to be accelerated due to efficiency-gains that can be realised by better work-flows as a result of more realistic planning assessments.

**The Last Planner application**

The theory for the system, as seen above, is well consolidated. However, the question that guided the research was: “is the application of the LPS technique as defined as the theory?”. In seeking for further enlightenment, this current work gathered data on 21 academic studies about the Last Planner implementation through case study reports. The method used to analyse all the reports is described in the next section, ‘The Literature Review / The Method’, and the results from this analysis are explained in the third section, ‘The Findings’.

**Importance and related works**

The research highlighted important topics and attempts to explain the difficulty in translating the LPS theory into practice. This was considered important to the academia as well as industry practitioners. Besides, the study identified that the absence of several details in published reports could end up fostering an indistinct pattern in the implementation of LPS technique in construction scheduling. The literature review found only one more study similar to the one reported in this paper. In this one, 17 articles were analysed, published between 2000 and 2009 (Porwal et al, 2010). Some of the findings between that research and the research presented in this paper are similar, but the conclusions differ in a way that both researches complement each other.

**2 THE LITERATURE REVIEW / THE METHOD**

The research commenced with a literature review on the Last Planner theory, in order to have a robust base of the implementation of LPS. Seventeen different studies were initially considered. Later, the re-
searchers conducted a systematic data processing, in order to capture the first-hand experience of construction organisations that have adopted the LPS implementation strategy. It was therefore necessary in this work to obtain information on real-life projects focusing on specific projects, and undertake the analysis of data collected from several construction projects that utilised the LPS technique. Considering that the Last Planner System has been in existent for only about 22 years, and it is only since Year 1997 (Grenho, 2009) that LPS has received attention from the industry, the researches chose to narrow the research to papers published between 1999 and 2015.

The researchers used online platforms and online search tools for academic studies: Google Scholar, the research tool owned by Edinburgh Napier University (United Kingdom) - LibrarySearch, the online National Library of Scotland portal, and the one owned by the University of Campinas (Brazil) – SophiA SBU. In the majority, these tools redirected to online archives: International Group for Lean Construction (IGLC), Lean Construction Institute (LCI) and its journal, Research Gate, Emerald Insight, ProQuest, Elsevier, Winter Simulation Conference (WSC), Hindawi, Routledge by Taylor & Francis Group, Journal of Engineering, Project and Product Management (EPPM), Wiley-Blackwell, and Brazilian National Association of Technology in the in the Built Environment (ANTAC) – non-official translation, or yet, to publications by other Universities around the world.

The analysis of each paper involved systematic screening on important subjects. This were allocated into one of the eight columns at the original table elaborated by the researchers. There were specific categories, such as the author’s names, the data about the case study (name of the project, country where was built, business operation, value and duration, and subjective categories, such as application, benefits and miscellaneous. The original table was adapted to the purpose of this paper, resulting in the table 1, that presents part of collected data added to other details considered important for the understanding of the study. It is important to notice that each number represents one academic publication, and not a case study. The academic works are arranged base on the year of publication The different papers that focus on same case study are marked with an asterisk on the ‘Ref’ column.
<table>
<thead>
<tr>
<th>Ref</th>
<th>Paper's name</th>
<th>Authors</th>
<th>Year</th>
<th>Case Study</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a) University laboratory building; b) design and installation of building envelopes; c) university old chemistry building renovation project; d) seismic retrofits of laboratory and office buildings biotechnology company (all above in the US).</td>
<td>a) Research: Dec 1997 – Mar 1998 b) Research: 41 weeks until Oct 1999 c) NI** d) Research: Jun 1999 - Oct 1999</td>
</tr>
<tr>
<td>03</td>
<td>The Last Planner System of Production Control</td>
<td>Ballard</td>
<td>2000</td>
<td>University office building construction (UK)</td>
<td></td>
</tr>
<tr>
<td>04*</td>
<td>Managing workflow on design projects: a case study</td>
<td>Ballard</td>
<td>2002</td>
<td>Enclosed amphitheatre (US)</td>
<td>1998 - Feb 2000</td>
</tr>
<tr>
<td>05</td>
<td>An experience of introducing last planner into a UK construction project</td>
<td>Johansen, Porter</td>
<td>2003</td>
<td>University office building construction (UK)</td>
<td>NI</td>
</tr>
<tr>
<td>06</td>
<td>Experience and results from implementing lean construction in a large Danish contracting firm</td>
<td>Thomassen, Sander, Barnes, Nielsen</td>
<td>2003</td>
<td>Danish company</td>
<td>2002</td>
</tr>
<tr>
<td>07</td>
<td>Site Implementation and Assessment of Lean Construction Techniques</td>
<td>Salem, Solomon, Genaidy, Luegning</td>
<td>2005</td>
<td>1st phase of a 4-floor university garage, 133,500 sq. feet (US)</td>
<td>81 days</td>
</tr>
<tr>
<td>08</td>
<td>Assessing the Impacts of Implementing Lean Construction</td>
<td>Alarcón, Diethelm, Rojo, Calderon</td>
<td>2005</td>
<td>77 construction projects from 12 companies (Chile)</td>
<td>Research: 2001 - 2003</td>
</tr>
<tr>
<td>09</td>
<td>Introducing last planner - Finnish experiences</td>
<td>Koskenvesa, Koskela</td>
<td>2005</td>
<td>4 projects from different companies (Finland)</td>
<td>2003</td>
</tr>
<tr>
<td>10*</td>
<td>Last Planner System impact evaluation on the Civil Construction Enterprises Performance</td>
<td>Moura</td>
<td>2008</td>
<td>Construction companies (Brazil)</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>11*</td>
<td>A quantitative analysis of production planning and control metrics: impacts of the Last Planner System and factors that affect its effectiveness</td>
<td>Moura, Formoso</td>
<td>2009</td>
<td>Construction companies (Brazil)</td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
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</tr>
<tr>
<td>13*</td>
<td>Improving Construction Workflow - The Role of Production Planning and Control</td>
<td>Hamzeh</td>
<td>2009</td>
<td>Hospital Project (US)</td>
<td>Validated: 2007 commence: Jan 2015</td>
</tr>
<tr>
<td>14</td>
<td>Production Control Principles</td>
<td>Ballard, Hammon, Nickerson</td>
<td>2009</td>
<td>a) NI (US) b) 9 buildings (US)</td>
<td>a) 30 weeks from Mar 2008 b) 1st building: 29 months</td>
</tr>
<tr>
<td>15*</td>
<td>Last planner system: Experiences from pilot implementation in the Middle East</td>
<td>AlShaim, Tzortzopoulos, Koskela</td>
<td>2009</td>
<td>Large state-owned construction projects (Saudi Arabia)</td>
<td>17 months</td>
</tr>
<tr>
<td>16</td>
<td>Construction Management Optimization – Last Planner System applied to a Case Study</td>
<td>Figueiredo</td>
<td>2009</td>
<td>Hospital construction</td>
<td>Research: 3 months. Construction: 21 months</td>
</tr>
<tr>
<td>17</td>
<td>Improving Construction Workflow - The Role of Production Planning and Control</td>
<td>Hamzeh</td>
<td>2009</td>
<td>a) 3-story medical office building (US) b) Rehabilitation of 23 buildings (US) c) University cardiovascular research centre (US)</td>
<td>a) 25 months (2006 – 2008) b) NI c) NI</td>
</tr>
<tr>
<td>18</td>
<td>A Survey on the Last Planner System: Impacts and Difficulties for Implementation in Brazilian Companies</td>
<td>Viana, Mota, Formoso, Echeveste, Peixoto, Rodrigues</td>
<td>2010</td>
<td>Several companies (Brazil)</td>
<td>NI</td>
</tr>
<tr>
<td>19</td>
<td>Reducing plan variations in delivering sustainable building projects</td>
<td>Ochoa</td>
<td>2012</td>
<td>Sustainable building project of two residential towers with 69 floors each (Hong Kong)</td>
<td>17 weeks</td>
</tr>
<tr>
<td>20</td>
<td>Last Planner System – a step towards improving the productivity of New Zealand Construction</td>
<td>Fueman, Puolitaival, Davies</td>
<td>2013</td>
<td>3 large companies (New Zealand)</td>
<td>NI</td>
</tr>
<tr>
<td>21</td>
<td>Modeling the Last Planner System Metrics: a Case Study of An AEC Company</td>
<td>Hamzeh, Arici</td>
<td>2013</td>
<td>Advanced electronic company (US)</td>
<td>12 months</td>
</tr>
</tbody>
</table>
In the course of the analyses, the researchers identified statistically significant comparisons and observations that are presented in the next section - ‘The Findings’. However, the information in some reports hinted at a prevalent limitation. It was common in the publications to report on qualitative data of the projects, but there was not commensurate quantitative information, that could shed light on the performance attribute of the projects. A critical missing information in many of the studied reports was the project cost, or how many percent of the project has exceeded or saved the final predicted value. Another lack of information was the project duration, or if the project could be finished on time or not, having exceeded the predicted limit, or having finished within the needed time. Even PPC measures were not present at all, in the reports, as the researchers supposed initially.

Although cost was a scarce data, it was possible to reach conclusions through it. Table 2 relates the costs of the cases that revealed such data, without the ones that omitted crucial information. The “case study” was repeated in order to facilitate the correlation between cost and project. The table is ordered according to the cost, from the cheapest to the most expensive.

Table 1 researched papers basic data

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Cost ($)</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large state-owned construction projects</td>
<td>010.0 Million</td>
<td>15</td>
</tr>
<tr>
<td>Danish company</td>
<td>015.7 Million*</td>
<td>06</td>
</tr>
<tr>
<td>Medical Office Building (three-story medical office building)</td>
<td>019.4 Million</td>
<td>17(a)</td>
</tr>
<tr>
<td>Large state-owned construction projects</td>
<td>021.0 Million</td>
<td>23</td>
</tr>
<tr>
<td>Hospital construction</td>
<td>035.4 Million</td>
<td>16</td>
</tr>
<tr>
<td>Northumbria University office building</td>
<td>036.3 Million</td>
<td>05</td>
</tr>
<tr>
<td>Rehabilitation of 23 buildings</td>
<td>045.0 Million</td>
<td>17(b)</td>
</tr>
<tr>
<td>9 buildings</td>
<td>001.0 Billion</td>
<td>14</td>
</tr>
<tr>
<td>Cathedral Hill Hospital Project</td>
<td>001.7 Billion</td>
<td>12, 13</td>
</tr>
<tr>
<td>Cardiovascular Research Centre for University of California</td>
<td>181.0 Million</td>
<td>17(c)</td>
</tr>
</tbody>
</table>

*average estimated between the most expensive and the cheapest project

*Some papers broach the same case study. This happens to the papers 01, 02 and 04; 10 and 11; 12 and 13; and 15 and 23.
**NI – Not informed
3 THE FINDINGS

The authors conducted a survey on the projects, and the general observations was that a hundred per cent of the cases experienced general improvement in the project delivery, when LPS was implemented. However, all the cases had also some difficulty in translating the LPS theory into practice, and the convergence of these problems resulted in the other findings presented on this section, which are

- The Last Planner system is possibly only applicable for big projects, or
- The LPS is applicable to small projects only if there is an adaptation on the lookahead schedule;
- The PPC has too broad definition, what can cause wrong conclusions;
- The LPS may not be applicable to Design-Bid-Build.

3.1 The Last Planner System: big projects versus small projects

According to Moura (2008), the success of the Last Planner System (LPS) depends on the existence of many variables to be manage. Similar to this, is that, LPS would not be a good tool for a small project, once there is less variables and the bureaucracy would only confound and create a barrier to the project progress. Koskela et al (2009) reveals that the scarcity of specialized labour can be a reason for the difficulty in following the LPS, therefore contributing to thinking that LPS may be not suitable for small projects, once they commonly have deficiency on specialized labour.

The definition of “small” and “big” projects, on the other hand, is not established, being subjective and its separation seems rather tenuous. From the various cases examined during the research, it could be observed that many types of projects uses the Last Planner System with at least a small progress, as already quoted. From $10 million to $1.7 billion US dollars projects, consisting in hospital constructions, buildings, offices, rehabilitation of several buildings, research centre, enclosed amphitheatre, sustainable and residential tower with 69 floors, a four-floor garage, laboratory building, installation of building envelopes, the Last Planner System can at first sight be considered a broad system that covers any project size. Although, a deeper analysis in the literature reveals that, actually, there is possibly no study covering the use of LPS in small projects. In this work, it was considered big projects, as those exceeding 30 million dollars in project cost,; medium-sized projects as those having project cost between $2 million and $30 million; and small projects are projects that cost lesser than 2 million dollars. The research done did not find any reported case of LPS applied to small projects. Indeed, it is not common to find the description of using the Last Planner System, for example, in the construction of a family house.

3.2 Adapting the lookahead schedule

In order to test Moura’s hypothesis, the best confirmation would be an empirical test by future works. Although this research had suspicions regarding Moura’s hypothesis, it had limited information to proceed on this line of inquiry. Ballard’s et al (2009) work, however reported a successful adaptation of a six-week lookahead planning to three-week lookahead planning for small projects or individual construction work. This paper did not examine the adaptation in further details, but the idea of adapting illustrates the crucial consideration that must be done: if the original format of LPS is not suitable for small projects, adaptations can be done, once the system is based in the general theory of management, what includes
all project sizes.

3.3 The definition of PPC

Moura (2008) presents another concern about the LPS theory, questioning the definition of PPC. Quoting Costa, Moura (2008) highlights that the weekly tasks can be managed in order to produce artificial results for the PPC, ignoring the quality requirements proposed by Ballard and Howell (1997). This problem relies on the broad definition that the PPC has, something that Breternitz (2002) had already noticed when proposing another metric to the LPS. According to his work, the PPC is not capable of considering incomplete works, for example, half work. For the PPC metric, it does not matter if determined task was 99% or 1% done – in both cases, it will be considered undone. As Moura (2008) stated, tasks broken down into smaller packages of work, have higher chances of resulting in higher PPC rates.

The broad definition of PPC can explain why the PPC behaviour is so different from one project to another or even inside just one project. It is observed that commonly the variation in PPC measures tends to narrow as the project matures, but the amplitude remains wide. Ochoa (2012) gathered data about an enormous project, recording also the PCC measures, which resulted in the graphic shown in Figure 2. The rising values are explained inside the study as direct result of the LPS acting, but the large amplitude between the recordings during the first 9 weeks can be explained by PPC’s broad definition.

Figure 2 PPC measures in Ochoa (2012) research, adapted graph showing the project first weeks

In Figure 3, it is presented the PPC performance in two more case studies that also confirm visually the high amplitude in PPC measures during the whole projects.
Among the case studies analysed in this research, the amplitude is also observed in Ballard (1999), in Alarcon et al (2005), specially on the last year of a three years research; and it happens again in AlSehaimi et al (2014) with the two researched projects.

3.4 LPS to Design-Bid-Build projects

At first, LPS was developed to be a tool to be used only during the construction itself. Ballard and Howell (2000), although, predicted the benefits that would emerge from implementing LPS since the project beginning, in the design phase. Nowadays, the current practice indeed apply LPS since the project early stages, but it has brought unpredictable questionings. Fuemana et al (2013) identified in his research two main problems relating LPS in the early stages of the most traditional way of contracting – the Design-Bid-Build project, where two different contractors execute the design and the construction phases.

The first problem is that LPS requires more from the designers. In traditional procurement systems, the designers do their work in the first phase of the project, and it is not required much more after that. The Last Planner System break with this model, requiring the designer participation until the end of the project, what makes room for defects or rework. Therefore, it was clear in Fuemana et al (2013) that there is a reluctance from the designers, creating a need of raising awareness.

The second problem related was the investment done in the design. It is intrinsic of LPS that a bigger amount of cost will be invested in the design, but the investment is quickly recouped and paid back during the construction, once waste of time and resource are avoided. This LPS characteristic becomes...
a problem in a Design-Bid-Build project because there is no total guarantee that the company will be awarded the construction contract, and if not, all the investment may be in vain. Future studies can develop a LPS adaptation to Design-Bid-Build projects, but until then, it is recommended to adopt the LPS in case of high levels of certainty.

4 CONCLUSION

The Last Planner System (LPS) is a generic application of lean thinking in construction project scheduling. It challenges the traditional approach of delivering construction projects, and incorporates a more dynamic approach to project planning. This work on the application of LPS suggests promising results, but there are also areas of improvement. For instance, it is suggested that LPS embraces additional flexibility that can enhance its applicability in construction projects. This will be beneficial for construction industry practitioners and project managers.

The research sought for convergent points in the case studies that indicate the state-of-art of the Last Planner System. The researchers conclude that the Last Planner System must be improved in order to conveniently utilise the approach in small construction projects. One possible way to start with this is working upon the lookahead schedule.

Another important observation was that the assessment of projects based on Percent Plan Completion (PPC) levels can be a reason for the divergence observed in the data of different projects implemented using the LPS technique, or even in same project. The solution can appear to be simple – to create a narrower pattern. However, this needs to be extensively studied in order to obtain more consistent and reliable results.

The research also examined the application of LPS in Design-Bid-Build projects, reaching the conclusion that the decision is up to each project team after studying the cost-benefit of using LPS in construction projects.

Finally, it was found that, in a hundred per cent of the cases, the Last Planner System delivers improved project performance compared to traditional techniques. All the project participants interrogated suggested that the Last Planner System achieved a general improvement in the delivery of construction projects. This findings support the hypothesis formulated in the beginning of this section. All the case studies attest to improved efficiency levels in the project completion time and enhanced inclusivity and bonding of the project team, when LPS is used in managing projects.

For future research, the authors suggest the development of a more holistic approach for reporting on the application of LPS. The researchers also suggest future studies on the adaptations that need to be done in the LPS approach.

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The “Theory of Catastrophes” as heuristic-hermeneutic innovative platform for the organization and management of change and risk in complex projects

Marco Fregatti

Purpose of this paper

Outline a methodology that, through qualitative and quantitative models, allows to interpret and face effectively change, conflict, risk and uncertainty, caused by sudden and unexpected variations in the evolution structure of systems, their trajectories and relations that intersect and interconnect in highly complex projects.

Design/methodology/approach

- Moving from:
  - theory of catastrophes;
  - researches in algebraic topology on the concept of “edge”;
  - study of stable “singularities”;
  - theory of analogies;
  - geometrization projects of “not exact” sciences;
  - interdisciplinarity;

the study aims to define a “methodology/language” that allows to organize experience data and to classify the phenomena of different nature in “axial” conditions, namely of abrupt change of the evolution structure of a “system”.

Findings and value
Identification of “models”, not “exact” solutions, which allow to interpret the events causing a sudden transition from one behavior to another and to clarify how these phenomena develop and why, suddenly, become “catastrophic”, inducing an unexpected change in the systems evolution.

Research limitations/implications

Embryonic research, which must be confirmed by subsequent studies and applications, especially with reference to its quantitative outcomes.

Practical implications

Identification of analytical techniques that allow:

- the recognition of legislative/normative tools and barriers that inhibit the processes of growth and development;
- the recognition of methodologies/technologies available to remove the above mentioned obstacles;
- the recognition of methods/tools available to manage and organize risk, change and innovation;
- the recognition of economic and financial available resources.

Originality/value of paper

Completion of traditional knowledge areas (P.M.I.) of Portfolio/Program/Project Management with challenging and innovative methodologies, based more on Learning than on Planning, attributable to:

- Innovation Management;
- Change Management;
- Catastrophe Management
- Collaborative Intelligence Management;
- Network Management;

in order to strengthen the technical, behavioral and contextual competences (I.P.M.A.) of a new executive class, called to lead complex projects of sustainable development, in particular conditions of risk, objectives variability, change and crisis.

Conclusions: The theory of catastrophes is here considered as a “branch” of dynamical systems theory and is configured as ideal heuristic-hermeneutic “platform” of an “axial” age, that is where the history changes trajectory, as it is possible neither conservation nor the increasing, but it requires a quality leap with change of direction, namely a conversion beyond the crisis, for a new development model.

Keywords: Catastrophe, Risk, Change, Innovation, Learning.
1 INTRODUCTION TO AN EPISTEMOLOGY OF THE CATASTROPHES

1.1 The epistemological basis of the relationship between phenomenological continuity and discontinuity

Krzysztof Pomian, in the Einaudi Encyclopedia (1977-1982), under the heading “catastrophes”, showed that the men of science have admitted, as if it were an axiomatic truth, that the causes whose actions vary continuously may cause only continuous changes in the effects. Of course, since the second half of the nineteenth century, were known exceptions to this rule, but they were considered marginal.

Rarely made explicit, the axiom in question, which can be defined as “axiom of conservation of continuity”, was taken into consideration especially by those who saw the difficulties in it or who disputed it for philosophical reasons.

The first of those are well represented by Georges Cuvier: a whole series of observations led him to conclude that the Earth’s crust had undergone very profound changes in the past, which were accompanied, each time, by the disappearance of living species. These “revolutions of the surface of the globe” had, according to Cuvier, a violent and sudden character, they were breaks of continuity, or “catastrophes”. Cuvier examined four factors that altered the surface of the continents: the rains and thaws, running water, the sea and the volcanoes and showed that they were not enough to cause the observed effects because their excessive “slow” would have made it impossible for the explanation of sudden disasters.

The “slow causes” are simply those whose actions vary continuously and for this reason Cuvier believed that they cannot cause catastrophes. But these are, according to Cuvier, duly noted by a variety of observations. Consequently, by virtue of a simple logical law, the causes which are responsible of them must have in turn a discontinuous character. However, Cuvier cannot conceive of such “sudden causes”, so do not talk at all, and all his geological theory remains to be suspended in the void. The difficulties for Cuvier result in particular from the fact that he admits simultaneously the axiom of conservation of continuity and the empirical observation of the presence of catastrophes in nature. Since the two are difficult to reconcile, it was necessary or to deny the reality of the “revolutions of the surface of the globe” or to get rid of the axiom. But the second solution was unacceptable for men of science, for which, and this now since the seventeenth century, the only true explanation of the phenomena was the one that integrated them in this or that quantitative model, that is, in a system of equations that defined the evolution of certain parameters in relation to others; among them a special place belonged to the time.

The explanatory power of such a model depends, first, by the character and the resolution capacity of measuring instruments that you have. But the explanatory power of a quantitative model also depends on the richness of mathematical language and on its ability to describe the different functions. All relationships that the mathematical language cannot indicate, and for which it has no formulas, are inconceivable in the framework of a quantitative model and must, necessarily, be left aside. This is not to say that there is disinterest of them: it is spoken in everyday language, which allows you to give an account of the results, observations and experiences; but this is considered just a gimmick and the ideal is to be able to have only quantitative models.
In fact, “nothing makes a mathematician more uncomfortable than a discontinuity, because every usable quantitative model is based on the use of analytic functions, then, continuous” (Thom, 1985). It follows that, when you consider that the set of phenomena can be explained, in principle, within the framework of a quantitative model (or quantitative models), you have to admit that all interactions between the phenomena are left to represent with analytic functions, namely that the discontinuities, that are observed, are only apparent. In other words, the argument for which the causes whose actions vary continuously can only cause continuous variations of the effects should be erected in an universal validity rule.

The philosophers were not subject to such obligations and it is precisely in the texts of some of them that you can better see the consequences to which led the refusal of the axiom of continuity conservation. Take the example of Hegel (The Science of the Logic, 2010): the “quantitative” is synonymous with the parameterized “continuous”. The change that is of the order of “gradually” consists in an increase (or a decrease) of this or that magnitude, without apparently affecting the identity of the being that changes, defined as the permanence of its properties not measurable, and of its “qualities”. If you are sticking to this appearance, the qualitative change, which is a break of continuity, a “jump”, seems not at all linked to quantitative variation. But, according to Hegel, this link exists. “The water, with the temperature change, not simply becomes less hot, but it goes through the solid, vaporous and liquid states. These different states does not arise gradually, but the simple gradual progress of the temperature change is indeed interrupted and stopped suddenly by these points, and the takeover of another state is a leap. Every birth and every death, instead of being a continued “gradually”, are indeed a truncation of “gradually” and the leap from the quantitative change into the qualitative change”. This is also the position of Marx (The Capital, 2013) who, studying the transformation of the capital value, observes: “Here, as in the natural sciences, it is proved the validity of the law discovered by Hegel in his “Logic”, for which changes merely quantitative evolve to a some point in qualitative differences. Engels will resume the same ideas in the AntiDühring (2015).

We know today that the intuition of Hegel was right. In fact, generally speaking, it is not true that the causes whose actions vary continuously can only lead to continuous variations in the effects. It is actually a very strange law that merely states that “purely quantitative changes are resolved at a certain point in qualitative differences”. In other words, what are the necessary and sufficient conditions because the causes which act continuously can cause the appearance of discontinuities. Neither in Hegel nor in Marx nor in Engels, you find answer to this question, and this implies that the link between “causes and effects”, between the “quantity and quality” remains for them, and for their readers, completely opaque.

In addition, both Hegel and Engels proceed by way of exemplification. When they try to obtain a general rule, they come only in vague formulas, purely verbal, that do not allow to better understand what you are talking about, and even less to predict anything, except what you already knew. Moreover, as regards more particularly Hegel, rejecting the axiom of conservation of continuity, he was forced to deny the ability of mathematical language to describe the set of phenomena.

In fact, Hegel emphasizes the continuity breaks, the “jumps”, on which the mathematical language of his time has no hold. According to him the quantitative variation slips, so to speak, on the outside of the being; only the transition from one quality to another has an ontological meaning. Conclusion: the common language is the only one able to give an account of reality in its totality. Although Hegel indicated at the
same time in a very relevant way the limits of mathematical language, he did not have to propose to men of science anything much more than a program closer to the tradition of Aristotle than to that of Galileo.

No wonder then if it did not have the slightest influence on the evolution of scientific research. The same applies to the dialectical materialism which refers to Engels: despite their pretensions of science, the representatives of this current were systematically in conflict with science. The theory of relativity, the quantum mechanics, the Mendelian genetics have met, for their part, as fierce as a vain resistance, and the list could have been longer. From the point of view of men of science, the preservation of the continuity axiom was untouchable: they were therefore obliged to treat the continuity breaks as if they were only apparent, to reduce them to continue variations. So to return to the example of the geology, Lyell showed that the transformations of the Earth’s crust were not catastrophic. He does not attribute them to mysterious upheavals, concentrated in very short periods of time, as did Cuvier, but to the slow action of the sludge, of the temperature fluctuations, of wind and water, that is, to infinitely small changes that cause spectacular effects only why they are added continuously over the course of millions of years. In doing so, Lyell introduces a new approach in geology. To explain visible breaks to the naked eye, he invokes subtle changes that occur continuously. At the same time, he changes the time scale that undergoes an expansion and accommodates a large number of such changes, whose integration leads to visible transformations. Sure, Lyell described the geological phenomena in the common language; however, his approach was similar to that of a physicist who uses a quantitative model. In the two cases, in fact, a visible or macroscopic discontinuity is substituted by a microscopic and continuous process, proceeding simultaneously at a time dilation. The discontinuity is thus revealed only apparent, not produced by the same things but from the way we perceive them. This allows to use the mathematical language available in form of the differential and integral calculus, but also obliges us to constantly increase the resolving power of observation and measurement instruments to be able to go down deeper into the microscopic world and to have the parameters which can be put into quantitative models.

However, a system of ordinary differential equations, which serves to describe the evolution of these or those variables in function of time, is difficult to use, or even clearly unusable, to study two types of situations. The first is that of objects which remain unchanged for a long period and then they undergo abrupt changes. The second, and more important, is that relating to complex systems, when they put into play a large number of variables that cannot be grouped into a small number of classes or that, if this grouping is possible, cannot be reduced to medium within each of these classes.

The first to be interested in the situations of this second type seems to have been Maxwell. The February 11, 1876, he spoke in the club who attended in Cambridge a conference that even today one cannot read without astonishment, to the point where certain passages remain relevant despite the 140 years that have elapsed since then. But the title of the conference is there to recall the intellectual climate of the time: “The progress of physical science does it tend to benefit the opinion of the need (or determinism) compared to that of the contingency of events and the freedom of the will?” Presenting his answer to this question, Maxwell is led to pose the problem of history and that of prediction. The question is whether, starting from the present state, known, of an object (today we would say rather: a real system), you can deduct, on the one hand, the states passed of the object itself and, on the other hand, its future states.

The problem that, in the language of Maxwell, is enunciated as that of the possibility to infer the future
state of an object from its present state, is precisely that of the possibility of using a system of ordinary
differential equations to describe the evolution of a real system. In fact, an ordinary differential system
of equations has a solution that, starting from an initial state, determines one, and only one, trajectory
of the real system described by these equations. It therefore has to do with the problem of determinism:
the initial state of a system determines uniquely the sequence of its future states. And it also has to do
with the problem of the presence of discontinuities in real systems themselves: it is clear that whenever
a small variation of the initial conditions causes a large variation of the final conditions, occurs a prac-
tical indetermination on the latter by the first. It follows that the evolution of a real system in which
appears such a discontinuity cannot be described by a system of ordinary differential equations. The
problem that Maxwell faces at this point of his speech is as follows: what are the conditions to be met by
a real system because its future can be inferred from its present. This problem is formulated in a negative
way: what are the conditions that make it impossible for such a deduction. Here is the answer: “You can
do a lot of light on some of these problems by taking into account the stability and instability. When the
state of things is such that an infinitely small change of the present state will alter only an infinitely
small quantity status at a future point of time, the condition of the system, it is at rest or in motion, is
stable; but when an infinitely small change in the present state can cause a finite difference in the state
of the system in a finite time, the condition of the system is called unstable. “It is clear that the existence
of unstable conditions makes it impossible to predict future events, if our knowledge of this state is only
approximate and not accurate”(Maxwell, 1876). As shown, the Maxwell’s problem is precisely that either
Hegel or Engels had never placed. He responds stating that if the conditions of a real system are unsta-
able, the forecast of its future states is only possible to him who possesses an exhaustive knowledge of
its present state. In other words, the axiom of preservation of the continuity does it apply to all real sys-
tems? Maxwell’s answer is not definitive. It is affirmative, with regard to the cases in which “the course
of events is stable”, for instance where a small error in the initial data produces only a small error in the
result; so, for example, in the study of the solar system. And it is negative, on the contrary, when it has
to do with “other classes of phenomena that are more complex, and in which may be present instances
of instability, the number of these cases increasing, in an extremely rapid way, with the increasing of the
number of variables”.

The concept of determinism fought by Maxwell is that that refers to Laplace for which a demon, who
knew the initial states of all the particles of which the universe is made and all the forces acting, would
be able to deduce the complete sequence of its future states. Maxwell’s critique opposes all this two ob-
jections: first, that the subject of knowledge cannot be treated as a God; then the one that the presence
of singularities in some real systems makes it impossible the unique prevision of the future states of such
systems, as, near singular points, “influences, whose physical size is too small to be taken into account by
a finite being, may produce results of the highest importance”. This is because in the proximity of singu-
arities appear discontinuities between the causes and effects, ceasing similar causes to produce similar
effects. This leads thus to an image of the world in which the determinism of Laplace applies, at most, to
a few little complex system, but not to the universe as a whole. The higher up on the scale of complexity,
the more it has to do with systems whose future evolution is unpredictable to a human observer; it has
to do, in other words, with a practical uncertainty. It would be superfluous to specify the differences
between the critique of the axiom of continuity conservation made by Hegel or Engels and the one that
Maxwell presents in the conference which has just summarized and commented. It is however worth to
underline the fact that the criticism of the first leads to no discovery, since, if it is admitted once and for
all that the quantitative variations produce qualitative changes, the role of science is reduced to provide examples in support of this thesis. Maxwell’s critique flows instead to an invitation to privilege the study of singularities and instabilities, neglected to the advantage of continuity and stability, and thus leads to postulate a new research orientation. It is true that this call went unheeded, except for some authors who had no great influence: although Maxwell’s conference had been published in 1882, in fact, only now it is possible to find similar ideas at which, in the meantime, it has arrived for a different route. This long latency period is explained by the fact that the mathematical language remained, all this time, unable to master the discontinuities. Now, the mathematical language is not simply, in positivist key, a convenient notation tool that also allows to make calculations and thus obtain quantitative predictions: the role of mathematics in the scientific research is much more important and diversified.

In the first place, scientists unconsciously yield to the tendency of crop, so to speak, the real to the extent of the language that is available to them; to give to the real the properties that make it susceptible of description using such a language. The determinism of Laplace is a good example of such a procedure: it merely characterizes the universe so it can describe its evolution by means of a system of ordinary differential equations. Another example of the same procedure is provided by the axiom of continuity conservation, which turns into a dissertation assigned to real processes the inability of mathematical language, at a certain moment of its history, to grasp the link between the causes whose actions vary continuously and the discontinuous effects.

1.2 The qualitative and quantitative approach to the relationship between continuity-discontinuity of phenomena according to René Thom’s catastrophe theory

It is only during the 50th and 60th years that René Thom has worked out the theory called of catastrophes, formulating the theorem that bears his name and which establishes an intelligible link between the causes whose actions vary continuously and the discontinuous effects. On the origins of this theory, exposed as fully as possible in the book by Thom “Stabilité structurelle et morphogénèse (1972)”, the author himself explains in a previous article (1965): “The theory that I propose comes from the conjunction of two sources: on the one hand, my own research in topology and differential analysis on the problem called of the structural stability: given a shape geometrically defined by the graph of a function $F(x)$, for example, the aim is to see if this function is structurally stable, that is, if, disrupting the function $F(x)$ fairly, the perturbed $G = F + eF$ function still has the same shape (topology) of the initial function $F(x)$; on the other hand, the reading of the treaties of embryology, in particular of C.H. Waddington’s books, whose ideas of “chréode” and “epigenetic landscape” I thought were adapted very well to the abstract scheme that I had met in my theory of structural stability of differentiable functions and applications. This means that the theory has a great character of abstraction and generality, and its scope goes far beyond embryology or even biology”. The role of embryology that Thom so highlights is interesting for more than one aspect. The morphogenetic processes studied by this discipline are, in fact, among the most rebellious to the traditional mathematical language, because sprinkled with discontinuities of which you cannot get rid of, using the previously described approach. At the same time, were just the processes of this type, which, as they provided a general paradigm of each development and evolution, were enforced by Aristotelianism to which modern science opposed its belief that such a paradigm must be sought in the movement of a material point (or cloud of material points). Even those who have criticized this assumption of modern science have emphasized, rightly, its reductionist nature; it is in particular the case...
of Hegel that, in the passages cited, shows how the traditional scientific approach is unable to give an account of appearance and disappearance of forms, their birth and their death. Thom also takes the side of those who consider the morphogenesis processes as capable of providing a general paradigm of all evolution: “The universe show is a ceaseless movement of birth, development, destruction of forms. The object of all science is to predict this evolution of forms and, if possible, to explain it” (Thom, 1985). But this word “explain” has, in the language of Thom, a special meaning; it does not mean only “to enter into a quantitative model”, but also, and above all, “make intelligible, offer satisfactory qualitative representations”. The word “qualitative” in turn must be purged from all its Hegelian or Aristotelian aura. “We must also be convinced of a fact: following recent advances in the Topology and Differential Analysis, the access to a rigorous qualitative thinking is now possible; we know (in theory) to define a form, and we can determine whether two functions have, or not, the same topological type, the same shape”. That is what makes it possible to pose the problem of stability, which has already met in Maxwell, as a mathematical problem. It is known the definition of structural stability of a function: starting from here, it is clear that a function is not structurally stable, when a small perturbation is sufficient to change the topological type, the shape. When a small perturbation transforms the topological type of a function, a new form of this appears; it therefore produces a solution of continuity, a catastrophe. But the same catastrophes have shapes which in their turn are structurally stable.

Therefore, the Thom’s theory of catastrophes is at the confluence of the two previously analysed currents: the Aristotelian-Hegelian tradition and the Maxwell’s tradition.

In other words, using a qualitative model, Thom establishes a link between the causes whose actions vary continuously and the discontinuous effects. We can serve this purpose of an example and we will not now speak of “causes” but of “control variables”, not of “effects” but of “state variables”. Suppose, then, that the “courage” and “fear” of an individual facing a crisis situation can be measured and what is of interest is the probable variation of the behaviour of that individual as a function of these two control variables. If only the courage grows, the determination grows, until it turns into a “domain reaction”. If only the fear grows, the determination decreases, until it results in “resignation”. If there is neither courage nor fear, the individual remains in a neutral state. But what does it happen when the courage and fear grow simultaneously? The individual’s behaviour becomes unpredictable: it is just as likely to react dominating the situation and to resign. Figure 1 shows then that the probability distribution changes shape: instead of only one, it has two vertices divided by a depression.
Let's have the values of courage and fear on two horizontal axes, x and y, respectively.

We have the values of the determination on the vertical axis z, with the understanding that z = 0 means a neutral behavior. We can now plot the three-dimensional graph of z as function of x and y. On top of each point (x, y) of the horizontal plane, we mark that point z which represents the most likely behavior (taken from the corresponding probability distribution). It appears, from the theorem of Thom, that we have to obtain a surface similar to the cusp catastrophe, as it is illustrated in Figure 2.

The meaning of the graph is quite simple to explain. It represents in surface the morphological, or better phenomenological, changes that can intervene in a complex system based on the dynamic composition of two variables which act below the surface itself. The “game” of variables involves four phenomenological states: the prevalence of one variable on the other (1, 2), the balance (3), due to the mutual compensation of the variables, and instability (4). The instability defines a critical state that cannot last indefinitely. In fact, it tends to evolve catastrophically to the states 1 and 2. The catastrophe simply means that the surface morphology changes abruptly and unpredictably. It is the unpredictability, in fact, the essence of the unstable state, which can veer towards one or the other of the two morphologies. However, we can take notice of the catastrophe only after it took place.

For example, in Case 1, where there is only the courage, we get a single point marked (1) on the graph, indicating the domain reaction. The same is for Cases 2 and 3. However, in the interesting Case 4 we get two points scored (4) on the graph, indicating the two vertices of the probability distribution. In addition,
there is another point (4) between these two that indicates the less likely neutral behavior. The reason to include the less likely points as the most likely points on the graph is that this gives the graph a completely smooth surface. This result is remarkable, and it is one of the consequences of Thom’s theorem. Therefore, it is important to remember when using the catastrophe cusp that the intermediate portion of the surface (the portion below the upper ledge) always represents the less likely behavior. If now we represent the variations of the individual’s behavior through the movement of a point on the surface, which is located in Figure 2, called the Cusp, we see that is the structure of this surface that determines all the possible movements of the representative point and, among these, the abrupt transition from a domain behavior to that of resignation or vice versa.

**Figure 2** Representation of the variations of the behavior of an individual facing a crisis through the cusp catastrophe

It is just this surface (or a corresponding equation) that constitutes, in our example, the qualitative model through which we effect the conjunction between an observable discontinuity and the continuous variation of the control variables. It is even that (or a corresponding equation) that characterizes the topology type of the catastrophe, that is its shape. This surface is a graphic image of the state variable as a function of two control variables.

In our example, we were dealing only with a state variable, but one of the major results of Thom’s theorem is that whatever the number of state variables is (in other words, whatever the number of dimensions of the state space is), whenever we have two control variables (in other words, whenever the control space has only two dimensions), if a catastrophe appears, it will have the same form: that of the Cusp.
Generally speaking, through certain mathematical conditions that it is not certain to occur automatically, Thom’s theorem states that the topological types of the catastrophes, their forms, depend on the number of dimensions of the control space and, when this number is equal to or more larger than 3, on the number of dimensions of the state space.

However, for the dimensions of the control space equal to 3 or 4 (the larger dimensions are not interesting now, although they are studied by mathematicians), the topological type of the catastrophe remains the same for all the dimensions of the space of states equal to or larger than 2. Since the catastrophes that appear in the lower dimensions of the control space are also present in its superior dimensions, there are only seven catastrophes that may occur in a 4-dimensional control space, equivalent to the usual space-time; they are called elementary catastrophes and are reported in Table 1.

Table 1 Table of the Elementary Catastrophes (Zeeman - 1974)

<table>
<thead>
<tr>
<th>Catastrophe</th>
<th>Dimensions</th>
<th>Function</th>
<th>First derivative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crease</td>
<td>1</td>
<td>$\frac{1}{3}x^3-ax$</td>
<td>$x^2-a$</td>
</tr>
<tr>
<td>Cusp</td>
<td>2</td>
<td>$\frac{1}{4}x^4-ax-\frac{1}{2}bx^2$</td>
<td>$x^3-a-bx$</td>
</tr>
<tr>
<td>Dovetail</td>
<td>3</td>
<td>$\frac{1}{5}x^5-ax-\frac{1}{2}bx^2-\frac{1}{3}cx^3$</td>
<td>$x^4-a-bx-cx^2$</td>
</tr>
<tr>
<td>Butterfly</td>
<td>4</td>
<td>$\frac{1}{6}x^6-ax-\frac{1}{2}bx^2-\frac{1}{3}cx^2-\frac{1}{4}dx^4$</td>
<td>$x^5-a-bx-cx^2-dx^2$</td>
</tr>
<tr>
<td>Hyperbolic</td>
<td>3</td>
<td>$x^3+y^3+ax+by+cy$</td>
<td>$3x^2+a+cy$</td>
</tr>
<tr>
<td>Elliptical</td>
<td>3</td>
<td>$x^3-xy^2+ax+by+cx^2+cy^2$</td>
<td>$3x^2y^2+a+2cx$</td>
</tr>
<tr>
<td>Parabolic</td>
<td>4</td>
<td>$x^2y+y^4+ax+by+cx^2+dy^2$</td>
<td>$2xy+a+2cx$</td>
</tr>
</tbody>
</table>

We see that the concept of continuity solution or of catastrophe now loses the vagueness that made its use so difficult. The theorem of Thom ranks all possible elementary catastrophes in a 4-dimensional space-time on the basis of their topological types (for this reason, it is also called classification theorem). It is noted, however, that the forms of the catastrophes are structurally stable, although the same functions are not alike in close proximity to some points that are its singularities; in the example of the behaviour of the individual facing the crisis, it is obviously the case of point (4), in the proximity of which a small perturbation is sufficient to produce an abrupt shift from the domain reaction to the resignation or vice versa. Finally it appears, and it is not the least surprising result of Thom’s theory, that “you can create abstractly a theory of morphogenesis, purely geometric, independent of the substrate of the forms and of the nature of the forces that create them” (Thom, 1985).

Developing a mathematical language that allows to offer qualitative models of the catastrophes and in certain privileged cases also quantitative models (although this point is the subject of a lively controversy fueled by Zeeman, Isnard, Bari Kolata, Arnol’d and others), Thom’s theory answers to Maxwell’s invitation and made his desire to see the determinism of Laplace replaced by another form of determinism.
Of course, in the case of quantum phenomena, the determinism of Laplace failed fifty years ago, but it was still supposed to govern the macroscopic world. Now, the catastrophe theory leads to question its even monopoly in this field. In fact, wherever, in the course of time, discontinuities appear in the mathematical representation of a real process, the Laplace’s model ceases to be applicable, because the initial state of the process does not uniquely define the succession of its future states. In other words, where a discontinuity appears, the process becomes undetermined, if the determinism is conceived in the same way Laplace conceived it. Evidently, one can argue that the process is not undetermined, but, although determined, it is structurally unstable.

This is however, according to Thom, a purely verbal distinction: “No experimental criterion will allow to distinguish a structurally unstable and determined phenomenon by a basically undetermined phenomenon. Therefore, when you empty the problem of determinism of its philosophical dimension, it reduces itself, under the phenomenological aspect, to the following affirmation, that can hardly be denied: there are phenomena more or less determined; the more or less determined character of a process is expressed primarily through the continuity more or less smooth (differentiable) of the evolution of this process as a function of the initial conditions”.

Then the macroscopic world ceases to be governed by the determinism of Laplace and the problem of the determined or undetermined character, structurally stable or unstable, of the studied processes must have an answer that comes not from a profession of faith, philosophical or other, but from a concrete research that identifies, to borrow an expression of Thom, “the determinism islands” in the ocean of uncertainties.

And that is not all: calling into question the determinism of Laplace, Thom also reopens the dossier of the problem of the relations between the scientific language and the common language. To the traditional three centuries approach, which considers the world of everyday experience as the field of the appearance and leads to reduce the observable discontinuities to microscopic and continuous processes, he opposes his belief that the observed discontinuities are real.

Instead of trying to eliminate them, you have to start “from the macroscopic examination of the morphogenesis of a process, from local or global study of its singularities” and strive to climb “to the dynamics that generates it”. In other words, it is the whole question of the relationships between the microscopic and the macroscopic which is reformulated, since the theory of catastrophes, unlike those that dominate in physics or biology, focuses on the macroscopic and flows in the idea of a new orientation of the research on the natural phenomena.

2 THE CULTURAL CONDITIONS OF THE CATASTROPHISM TODAY: GLOBALIZATION AND MULTICULTURALISM FOR A NEW HUMANISM

2.1 The Age of the Globalization and Multiculturalism

Not unlike a “catastrophe”, as claimed by Maggiora (2014), the enlargement to a global scale of spaces, flows, relationships, what we now call “globalization”, is completely reshaping our view of the world. The spread of the information and communication networks approaches the lifestyles and consumption
trends in the world and, at the same time, tends to reset the differences between places, cultures, civilizations. It puts in contact with each other different visions of the world and cultural worlds, but also feeds fundamentalist reactions and closures.

It calls the great historical areas to find, through a reflection on their own and others identity, reasons and forms of their dialogue, but does not create the right conditions to face this task.

“Globalization” seems to result in a homogeneous world system dominated by a unique common “economic paradigm”. On closer inspection, things are different, the most profound impact of globalization invests the “cultural-communicative”, “religious-symbolic” and “anthropological” level.

Globalization poses in direct contact with each other regions of the Earth that were once separated by historical, physical, economic and cultural barriers, considered insurmountable.

Today, the world becomes to all effects smaller and interconnected. It must modular for itself a new score of communication and the watermark of this new score has to be necessarily and globally multicultural. Not for this the future world will be a flat space, composed of dots of equal importance. It will have its peaks of excellence in the large areas widespread on the planet, which will tighten a close dialogue with each other, made at the same time of competition and cooperation. A dialogue even more necessary if we want to prevent a devastating conflict of civilizations from which we risk going out all defeated.

If we adopt a multilinear point of view to development issues, we must ask ourselves how the differences of forms of life and culture have a role to play in the change.

“Multiculturalism” therefore contains immense potentialities for the future and can generate them only if it does not just acknowledge the existence of a multitude of inert side by side cultural universes, but it works actively to overcome the static nature of worlds mutually impermeable.

In the history, the story of exchanges and hybridizations among cultures in different areas of the world has not known an obligated or linear way; the great creative processes, that have changed the face of the territories, leaned not on the imposition of rigid models, but on the fruitful relationship among different worlds, capable of interacting with each other.

This is what happened in the great cultural exchanges in the Mediterranean Middle Ages, when, for example, Arabic philosophy, mathematics and medicine became sources of comparison, imitation and influence on European cultures: from the works of Aristotle to the love theory in Dante Alighieri, to the Arabic constructive knowledge, which contributed, for method, calculation and techniques, to the architectural humanism of Filippo Brunelleschi in his dome of Santa Maria del Fiore in Florence (Italy), icon and symbol of the new West's constructive rationality.

The broken paths can be taken, the concluded experiences may again become a source of new inspiration and insight and of operational and fruitful consequences.
2.2 An Axial Age for a New Humanism

The awareness that the present scenario of globalization has irrevocably opened a new phase of the history has synchronously involved the whole humanity. We live in an age of which already now we are able to perceive its most disturbing and destabilizing effects on the entire planet. An era that looks so full of novelties and potentialities, of alternatives and contradictions, of wealth and poverty, of excesses and deprivations, of opportunities and dangers, to be in itself today, as never before in the history, so fast itself, so rapid in its transformations, so disruptive in his reflections, so unsettling and dazzling in its epiphanies, to make restless and distressing even the minimum existential most immediate perspectives of the Man and, together, those of his own destiny.

We live, in other words, in an “axial age”, that is one in which the history “changes direction”, as it is possible neither the conservation nor the increase, but it is imposed a “conversion” or a jump of quality with a change of direction, that is that “catastrophe” which can be symbolically represented, on the basis of the considerations discussed up to here, as shown in Figure 3.

**Figure 3** Representation of the variations of the behavior of world people facing a crisis through the cusp catastrophe
In fact, many cultural problems of our present derive from the continuing tensions among cultural forms, in a historical period in which the theoretical, scientific and formalized culture claims to be the only viable way of relating to the world, driving out other modalities of experience, knowledge and action.

According to Maggiora (2014), it is therefore necessary to pursue the matter which, in the last half century, has been called the “new humanism” and grasp all the implications in terms of cultural design. In the essay “Les trois humanismes” now “Anthropologie structurale deux”, Claude Levi-Strauss discerned three forms of humanism emerging sequentially in the European West: the discovery of Greek-Roman Antiquity (the first Humanism), the discovery of the Great Oriental Civilizations (the Orientalism), the discovery of Primitive Cultures (the Ethnologism): “the western man has begun to realize that he would never understand himself as long as, in the face of the Earth, only one race or one people had been treated by him as an object”.

The new humanism aims to pass from the observation of the objective plurality of the worlds and cultures, which actually exists and is undeniable, to the recognition of a thoughtful pluralism, which becomes internalized attitude and spirit of cross-cultural relationship. His reasons consist in the effort to embrace with an unique look the multitude, without trying to subdue it to a judgment issued according to an unique principle, which emanates from the claim of the superiority of the culture that formulates it. “To keep the harmony of the diversity in the dialogue and meeting (which creates harmony even in the radical difference of the timbres of a bass and a soprano) is the goal of a genuine and fruitful multicultural, intercultural and inter-religious experience”.

Translating this principle into action, we realize that only the comparison of the voices allows to expand the “one-sidedness of the loner operating” and enter the “creativity of many” in facing global problems. That is the evocative notion of the “contextual universalism”: a story is a polyphony, a concert of voices and traditions, an open totality, in which are played always different balances; the polyphony involves the recognition of the variety of the contexts within a larger system”.

The twenty-first century will be vital, unlike the one that preceded it, if it will be able to give itself the profile of a time characterized by multiple voices, which are waiting to be composed in polyphony, not to cancel their variety, and to make the variety as a necessary resource for the universal harmony.

3 QUALITATIVE AND QUANTITATIVE STRATEGIES AND METHODOLOGIES FOR THE INTERPRETATION OF THE CATASTROPHIC PHENOMENA IN COMPLEX PROJECTS: THE ROLE OF THE CHANGE AND RISK MANAGEMENT & CONTROL

3.1 Qualitative and General Strategies and Methodologies for the interpretation and the management of the Catastrophic Phenomena in Complex Projects

On the basis of cultural assumptions highlighted in the preceding chapters 1 and 2, an important strategic factor to be pursued could, therefore, be made up of the possible transfer and application of the “Theory of Catastrophes” to the field of management of complex projects, in the sense that such a “theory” can here be considered as a branch of the theory of the dynamical systems and the term “catastrophe” can still here mean an abrupt change of evolutionary structure of a system and of its trajectory.
In other words, the above theory can be configured as an ideal “heuristic-hermeneutic structure” of an “axial age”, that is where the history, based on humanistic principles previously highlighted, changes trajectory, with a leap of quality, to orient itself to a new development model.

Paradoxically, in fact, the strong economic crises or the catastrophic natural events, such as the earthquakes or the hydrogeological instability phenomena, have also returned a bit of future to countries that have been affected, mainly with reference to the ability to react and the determination of local people.

In particular, when there are natural, social or economic-financial “major disasters or catastrophes”, “great laws” are required, which are often considered “special laws”.

One should not forget, for example, that after the earthquake that hit the Emilia-Romagna in Italy in 2012, today there is an “Emilia Protocol” which rationalized the emergency matter and made it possible to initiate procedures much more streamlined, simplifying the presence of 80 different protocols and 80 different authorization levels that blocked essentially the machinery of civil protection and institutional and private aid.

In the past, in fact, in the absence of a framework law that would allow the emergency governability, they had been issued several legislative measures, later followed by sequences of ordinances, which, in turn, faced different aspects of reconstruction.

In the same spirit of bureaucratic simplifying, even the administration of Milan in Italy, to implement the “New Plan of Government of the Territory” on the basis of eco-sustainability regeneration, degraded areas recovery and social housing relaunch, it has now reduced to an “one-step” the previous 19 steps to distinct administrative sections, necessary for obtaining a building permit.

“To rebuild”, therefore, also means “to do something different” to change the legislative framework of the State and of Local Authorities and to initiate a radical change, in a “catastrophic” form, in the general culture of the political and government apparatus.

From this point of view, a “complex project”, that is proposed as a model of a “new strategic platform” for the logistics, industrial, economic, social and cultural growth of a country, it must be supported, in its “complexity”, by a revision and simplification process of the legal and regulatory framework of reference, enabling more effective and efficient use of the huge public and private resources involved by it.

This “catastrophic” simplification should cover both the legal and operational architecture of the possible Framework Programme Agreements and the rulings necessary to start the realization of a variety of works, classified as “major” or “minor”, with the related approval and control procedures.

Only through these “catastrophic” processes of legal-regulatory and bureaucratic simplification, it is possible to pursue, in the context of such a project, the tight integration required in the design, approval, implementation and control of systemic and punctual solutions, able to determine an integrated infrastructure development.
To act, therefore, urgently, or in a “catastrophic” way, on the legal and regulatory simplification, it will be necessary to implement immediate appropriate analyses with the purpose of enabling:

- the recognition of the legislative and regulatory instruments and the obstacles that affect and inhibit the growth and development processes at level of:
  - Central Government;
  - Regional Government;
  - Municipal Administrations;
- the recognition of the methodologies, tools and technologies available to quickly remove the above obstacles;
- the recognition of the methodologies, tools and technologies available to manage and organize the change and innovation, to avoid having to deal with the emergency in all “catastrophic” cases in which it is proposed with evident dramatic configuration (economic-financial crises, social tensions, earthquakes, landslides, hurricanes, etc.);
- the recognition of the economic and financial resources, which are often resources allocated but not used within the framework of the European Structural Funds, State or Local Authorities Budgets, etc..

It must, in fact, consider that the bureaucratic structure of rules often blocks also funding, not just the processes of construction and industrialization.

The quality, regularity, fairness and legality of industrial and construction processes in the broadest sense, then, must be guaranteed by the companies; but it is necessary to cut bureaucracy and simplify the legislative and authorization systems within which they are operating.

The national prescriptive models can paralyze the single countries: they are much more effective a few prescriptive norms and many more controls, which, of course, in turn, should not be “driven” by bureaucratic apparatus, but to be lean and efficient, and classifiable in a logic of “Portfolio/Program/Project Management”, which aims to highlight the extent and quality of the results achieved and to ensure morality and legality in the realization processes.

The theme of the legal-regulatory simplification is, thus, the “theme of the themes”, because prefigures the need for a deep structural reorganization and a radical change, in a catastrophic sense, of the Public Administrations and of the political and fiscal Federalism.

In this configuration, however, the problem of the “Time” takes on also a crucial role, if we want to merge the organizational and management processes of Sustainable Development, Integrated and Innovative, of complex Territorial and Metropolitan Areas or Macro-Areas in a suitable Financial Plan. While, in fact, we are in some way addressing and resolving the problem of integration between Strategic Planning, Urban Planning and Systems Planning, it appears today still problematic the issue of integration of these schedules with Financial Plans.
On the contrary, the time factor is crucial today, especially to continue to be attractive and competitive as a country-system and not to aggravate the Budgets of the State, Local Authorities and Companies with more substantial economic and financial losses associated with the failure to meet the timing of realization and with the delay of the “do not make”.

In this new framework of “sustainability”, a complex project, which aims, as stated above, to become a strategic platform model for a logistic, industrial, economic and social growth of a country, must be based on an entrepreneurial and innovative prospective, no longer based solely on the paradigm of competition-concentration-disequilibrium, but rather on that of cooperation-distribution-balance, which, by creating “enterprise networks” and the application of the criteria of “sustainability” and “social and territorial cohesion”, redefines the main guidelines for the connection of peoples, cultures, economies and places, in the sense indicated in chapter 2.

In fact, the need to “build a sustainable business” not only has become urgent with reference to the institutional and regulatory instructions and commitments, but today it is the only opportunity that have the “companies”, of all sizes and sectors, so that stakeholders can acknowledge their right value and ensure their survival over the time.

Therefore, in order to act effectively and efficiently in accordance with the socially, environmentally and economically responsible way, any “Enterprise” is called to invest in an important “change” (catastrophe), which involves internal processes and relationships with its employees, customers, suppliers and partners, but also with communities and institutions taken in their complexity.

Hence, it emerges also the need for a radical change in the behaviour and also in the formation of the new Political, Cultural, Technical, Industrial and Entrepreneurial Executive Class called to lead and to realize a complex project, whose natural aptitudes and inclinations should be those not only to develop classically all the necessary processes to identify, define, combine, unify and coordinate the many activities, the various technologies, the complex procedures and the structured methodologies required for the management of a Portfolio of Projects, of a Program or of a single Project, such as the processes that, according to the traditional model of the “Project Management Institute”, are referred to:

- Integration Management;
- Scope Management;
- Time Management;
- Cost Management;
- Quality Management;
- Human Resource Management;
- Information and Communications Management;
- Risk Management;
- Procurement Management;
- Stakeholder Management;
or that, depending on the model proposed by the “International Project Management Association”, are related to the following three main areas of managerial skills (in particular grouping 46 distinctive micro-competencies):

- Technical Competencies;
- Behavioral Competencies;
- Contextual Competencies;

but also to complete and penetrate, with the conceptualizations and tools closely related to Sustainability, Social and Territorial Cohesion, Integration, Change, Innovation and Internationalization, all those areas of knowledge and all the skills that lie at the core of the culture of the “Portfolio/Program/Project Management”, which is the basis of a managing and organizational behavior that ensures not only “effectiveness” and “efficiency”, but also “sustainability” and “transfer of environmental, cultural, social and economic values” to the Communities that receive and use the final goods or services.

**Figure 4 Dynamic Innovative Principles for Portfolio/Program/Project Management & Control in “catastrophic” situations**
And it is especially in relation to such cultural and strategic acquisition that, in semantic, methodological and philological coherence with the distinctive characteristics of the “catastrophe theory”, it is required a thematic and applicative deepening of new cognitive domains, which appear to be challenging and innovative, such as those, additional to the previous lists (because not yet recognized by the “Project Management Institute” or the “International Project Management Association”), which are, rather, attributable to the following spheres of influence and action, as shown schematically in Figure 4, and appearing today more based on the “learning” than on the “planning”:

- Sustainability Management;
- Innovation Management;
- Change Management;
- Catastrophe Management;
- Knowledge & Learning Management;
- Collaborative Intelligence Management;
- Network Management;

with the main aim to initiate and strengthen organizational and management processes of Sustainable Development, Integrated and Innovative, in Territorial or Metropolitan Areas or Macro-Areas, more or less complex in terms of culture, technology, infrastructures, environment, society, economics and policy, re-establishing a new language that allows to organize the experience data in the most varied conditions, more susceptible of sudden and unpredictable changes.

3.2 The Role of the Change and Risk Management & Control for the qualitative and quantitative interpretation of the Catastrophic Phenomena in Complex Projects

The Change and Risk Management in so-called “catastrophic” conditions configures, as implicitly contained in the previous paragraph, a “Change and Risk Analysis Solution” that covers the entire life cycle of a complex project, integrating at least, by a part, the views of the “cost/income” and “time”, and, on the other, the related plans of “contingencies” and “responses to changes and risks/ opportunities”.

Through this solution can be implemented and ensured, both qualitatively and quantitatively, the following additional properties and functionalities, compared to the traditional ones:

- Methodology based on Change and Risk Analysis;
- Analysis of changes and risks/opportunities integrated with the schedule and the cost/income;
- Modeled estimates of the uncertainty;
- Qualitative and Quantitative Register of Change and Risk/Opportunity;
- Reports of comparison of multiple scenarios;
- Scheduling with mitigation of change and risk and impact on cash flow.
- In particular, the quantitative investigation processes allow to:
• perform a "multipoint" analysis ("Monte Carlo" type) on the analyzed program, consistently with an assigned shape/distribution (which, in catastrophe conditions, could be referred to the distributions and functions shown in Figure 1 and in Table 1) and a related impact assessment (minimum, maximum and most likely) on both the timing and costs;

• define the degree of correlation among the changes and risk events and their possible impacts;

• identify as soon as possible, within the project life cycle, potential areas of change, risk/opportunity and their potential impact on the costs/revenues and/or the planning;

• identify areas where you may need to add contingencies to the project;

• consider whether specific deadlines or budgetary limits are realizable;

• identify for each activity the minimum, most likely and maximum durations which are taken into account in the calculation of the corresponding probabilistic dates;

• assign each activity resources and costs/revenues, which, in turn, can have multi-point estimates related to them.

**Figure 5** Determination of the probability to meet the deterministic end date and cost of a Project in catastrophic situations

For example, using the iterative "Monte Carlo" analysis, we can see the effect that the changes and uncertainties have had on the completion dates and costs/revenues of the project: on graphs displayed in Figure 5, both in form of Gantt and histogram chart, are indicated both the probability to observe the deterministic end date of the project (that is the original end date, which can be derived from a planning tool without considering changes, uncertainties or risks), and the probability to observe the deterministic value for the costs of the project (which, in turn, represents the amount derivable from the planning tool without evaluating changes, uncertainties or risks).

These reports also represent the typical outputs of the following main analysis, both in the configuration of “Pre-mitigation/incentive” (place where all changes and risks/opportunities impacting on the program, both in terms of time and cost/revenue), and in the configuration of “Post-mitigation/incentive” (place of the most likely outcome after the application of the measures of mitigation/incentive of the changes and the risks/opportunities identified):

• "Monte Carlo" analysis, to perform "random" probabilistic simulations;
- “Sensitivity” analysis, to identify the activities most likely to be “driver” of the project;
- “Criticality” analysis, to identify the probability of the activities to be included in the critical path of the project;
- “Cruciality” analysis, to represent the relationship between “Criticality” and “Sensitivity”.

In particular, through the above analysis, it is possible to indicate to which level of confidence a complex project can be completed, both in terms of time and cost/revenue, in the case in which are taken all the necessary actions of mitigation/incentive of the changes and risks/opportunities identified for the same project, as shown in Figures 6 and 7.

**Figure 6** Post-mitigated and Sensitivity Analysis of a complex Project in catastrophic situations

**Figure 7** Criticality and Cruciality Analysis of a complex Project in catastrophic situations

The advantages of the comparison between plans, for the pre and post-mitigation/incentive of changes and risks/opportunities identified, as shown in Figure 8, will allow to:
• get the correct information about the mitigations/incentives available to make the right decisions and be sure to deliver the project on time and within budget, maintaining margins and reputation and avoid any penalties;

• view and compare the probabilities of completion dates and costs/revenues between plans of pre and post-mitigation/incentive, to see if and where the effort made for mitigation/incentive reveals a tangible result in terms of respect of the completion date and budget of the project;

• decide which level of mitigation/incentive measures must be guaranteed on the project, through an understanding of the associated costs and impacts on the planning and budgets.

Figure 8 Comparison between pre and post-mitigation/incentive plans of a complex Project in catastrophic situations

Finally, we will be able to view the impact of changes and risks/opportunities identified on the distribution of a project cash-flow, as shown in Figure 9, allowing to:

• understand how a project compares to a financial plan, in relation to changes and risks/ opportunities occurring;

• provide an overview of the probabilistic cash-flow through the evolution of the whole project, thus ensuring a holistic point of view, rather than a vision month by month;

• check where every cost is incurred, once the expected completion date is exceeded;

• ensure, with a certain degree of confidence, that the projects are analyzed from the point of view of
changes and risks/opportunities also in relation to their cash-flows.

These circumstances may facilitate financial planning, ensuring that expenditure is managed throughout the entire life cycle of the project.

**Figure 9** Impact of Changes and Risks/Opportunities on a complex Project Cash-Flow in catastrophic situations

Projecting the above considerations on the design and implementation of an informational Platform for the “Change and Risk Management & Control” in catastrophe conditions, the fundamental idea of Fregatti (2014) is that the “Web Services” are a key factor for the publication of “services” in a standard or disruptive way and that features such as “reusability”, “systems integration”, “flexibility” and “incremental and disruptive development” represent greater benefits perceived by different companies that are starting to use technologies and methods which refer, as shown in Figure 10, to SOA (Service-Oriented Architecture) architectures, in catastrophic situations.
Configured within this architecture opened to “catastrophes”, the “Change and Risk Management & Control Platform” will have to preserve, therefore, the following “technical-infrastructural characteristics”:

- “Smart Client Application” (to combine the best Web applications with the best traditional Client-Server applications);
- “Distributed and scalable Application” for heterogeneous scenarios (from the desktop to the Server Farm, etc.);
- “New interface paradigm”: “Windows Forms”, “Rich User Experience” (interfaces capable of supporting complex tasks) and “Office 2007 like look and feel”;
- “SOA” (Service Oriented Architecture): “service as business functionality”;
- “Microsoft WCF” (Windows Communication Foundation): “application services” (not just Web Services), usable regardless of the communication protocol (.NET Remoting; ASMX; MSMQ; .NET Enterprise Services; “TCP/IP” protocol for intranet scenarios, “http” protocol for web scenarios, etc.);
- “Microsoft .Net framework”: “service-oriented applications” for Windows;
- “Microsoft Click-Once Technology”;
- “ERP, Oracle-Primavera, etc., Interoperability”.

**Figure 10** Technical-Infrastructural Architecture for the Change and Risk Management & Control Platform
Included in this “complex and open architecture”, the “transactional characteristics” of the “Change and Risk Management & Control Platform” will ensure, to potential customers, a significant “productivity improvement” in the business processes involved in catastrophe conditions and an effective “cost reduction” in information processing, through:

- the alignment of data across different information systems, by means of reliable and easy to use functionalities;
- the support for “free” workflows, based on the characteristics of the contracts to manage, without imposing a priority in the “direction” of the alignments between different systems;
- the reduction of the weight of alignment activities and of their error rate;
- the speeding up of the process of “initial plan” creating (time-to-market in “Bid” or “Execute” phase);
- the reduction of the overall training weight and the increasing in the rate of re-usability of the “best practices”;
- the elimination of redundancies in the integration between “planning & control systems” and “estimating & accounting systems”;
- the lack of treatment for pre- or post-processing of input and output data;
- the completion of solutions and/or processing tools already in use, within companies, in the different phases of the project.

Likewise, the “informational characteristics” of this Platform will bring, within different companies and in catastrophic situations, a significant informational “quality improvement”, a tangible “control increasing” and an incremental information “customization degree”, through:

- the more quality and consistency of data in information systems;
- the integration of solutions and/or tools for estimating, budgeting and accounting (if necessary in details) of changes, costs/risks and revenues/opportunities;
- the separate management and the subsequent integration of solutions and/or tools for estimating, budgeting and accounting (if necessary in details) of works, mitigations/incentives related to the changes, risks/opportunities, contingencies, etc.;
- the integration of solutions and/or tools for the projection of changes, risks/opportunities, mitigation/incentive actions, contingencies, etc., on the activities and timing for project realization;
- the interconnection of the project structures (RBS, WBS, OBS, CBS, etc.);
- the integration and the extension, with simple and agile tools, of the changes and risks/opportunities management methodology and solutions, activated within the companies, to the whole chain of partners, subcontractors and suppliers involved in the production process;
- the possibility of implementing a structured and customizable reporting;
- the ability to customize and tailoring for business the analysis results.

Finally, the “strategic characteristics” of the “Change and Risk Management & Control Platform” will ensure to the different enterprise shapes a “competitive advantage” increasing over their competitors, an
“increasing in sales”, a “market position improvement” and a significant “product/process innovation” in catastrophic conditions, through:

- the integration of a service-oriented architecture with the flexibility and ease of use of an interface typically “Smart Client”;
- the interoperability of solutions and/or tools for planning, scheduling and control of the projects (Oracle-Primavera Systems, MS Project, etc.), for estimating and accounting of the works (STR-Vision Systems, etc.) and for organization and management of the company business (ERP Systems, etc.);
- the definition for users of an “optimal methodology” to be followed and applied to ensure proper and systematic approach to the project change and risk management and control;
- the creation of a “best in class” user-platform in the field of “Project Change & Risk Management”;
- the provision of extended functionality and a variety of functions of the platform.

**Figure 11** Conceptualization System for the Project Change and Risk Management & Control Methodology and Platform

The characteristics and functionalities drawn by this technical and functional specifications tend, therefore, to envisage a Platform for the “Project Change and Risk Management & Control”, that presents a particular “originality”, which well defines the overall properties of an “informational platform” capable,
on the one hand, to establish a common base of knowledge and of technological, methodological, organizational and managerial solutions, useful for the “Project Change and Risk Management & Control”, and, on the other hand, to enter fully between the initiatives that can be implemented, as schematically represented in Figure 11, to improve public and private companies products/processes and corresponding business models, having proposed to affect, in a tangible way, the decisive issue of the “uncertainty” and “catastrophic phenomena” in the “achievement of the objectives”, relying on “key words” for a “new development model” as “sustainability”, “innovation”, “change”, “catastrophe”, “knowledge & learning”, “collaborative intelligence” and “network”.

4 CONCLUSIONS ON THE HEURISTIC-HERMENEUTIC ISSUES QUALIFYING THE THEORY OF CATASTROPHES IN THE COMPLEXITY MANAGEMENT

The term “catastrophe” (from the Greek “katastrophé”: upheaval, overturning) has not, in its etymological sense, negative connotations. It takes on a technical meaning in Aristotle’s Poetics, where it indicates the time when it melts the plot, and therefore it is the critical point of the tragedy, characterized by the passage of the protagonist from one state of happiness to one of misery. It is, therefore, a sudden change, which, however, is subjected to a series of tragic art rules, so as to be similar to the “concept of catastrophe” drawn, as it has been said, by René Thom, in a complete form, in 1972, with the publication of the book “Structural Stability and Morphogenesis”.

René Thom presents, therefore, the “catastrophe theory” as an attempt of explanation of natural forms, of their presence, their genesis and conflicts on which it is based. The universe is more a “cosmos” than a “chaos” and catastrophe theory tries to explain its forms, regardless of the “substrates” (that compose them): “any form owes its origin to a conflict”, as return to the old “idea of Heraclitus” that conflict is the father of all things. Thom traces, then, briefly the main stages of the mathematical genesis of the theory of catastrophes: the researches in algebraic topology on the concept of “edge” (the most natural type of form), the “groups of cobordism”, the study of the stable “singularities” (for example, the cusp or “inversion point” of a caustic).

Underlying the choice of the term “catastrophe” there is, therefore, the idea that certain natural discontinuities are associated to the conflicting processes. Even the narrative structures can be interpreted according to “catastrophic” patterns, as shown by Propp’s studies on the Russian fairy tales or by the use that Christopher Zeeman has made of the Thom’s method in his system general theory, or even by the use of the “catastrophic” model in the interpretation of the French Revolution with reference to the problem of the legitimacy and the power.

The catastrophe theory proposes, by Thom, conceptual and mathematical metaphors and tools to explain areas of knowledge otherwise not strictly describable; it is a rigorous theory of the analogy, which also takes account of the richness of the language. For Thom, the most promising results of catastrophe theory could come, in fact, from metaphysical applications, precisely because it is to grasp not only the superficial structures, but also the deeper dynamics.

So, reflecting on the sociological connotation of the sciences, Thom says he is not a scientist in the modern sense of the term, but not even a philosopher; his fundamental vocation is rather the interdisciplin-
arity and the search for a common language to many different phenomena.

Therefore, even if the catastrophe theory was born in a strictly mathematical field, its importance lies in the geometrical design of those sciences that have long resisted to a mathematical analysis: such as biology and human sciences, namely “inexact” sciences. In this way, it differs, as already it has been claimed, by so-called scientific theories in the strict sense, because it does not necessarily require an experimental confirmation.

In fact, René Thom says:

“First we must be clear that catastrophe theory is not a scientific theory in the usual sense of the term. It is not, that is, a scientific theory as are, for example, the Newton's theory of gravitation, the Maxwell’s theory of electromagnetism or even the Darwinian theory of evolution. From theories like those you have the right to ask to be, in some sense, confirmed by the experience, that is, one may cite experimental arguments in their favor. But the catastrophe theory must not meet this request. The term "theory" should be understood in a very particular way: I would rather say that it is a method, if not a kind of language, which allows you to organize the data of the experience in the most varied conditions”.

From this passage, there are two important points, constant in the writings of the followers of the theory of catastrophes:

- the refusal to accept the experimental control among the criteria which give the right of existence to a scientific theory;
- the search for a methodology first capable of classifying the different phenomena.

The empirical necessity (experimental control) ties necessarily the generality of the theory to the contingency of the data of the experience. The denial of this requirement may cause the catastrophe theory to generalize the scope of the applications (theoretical, of course), without this extension should affect the theory itself.

The use of the term “catastrophe” here refers, therefore, to events that suddenly cause a switching behavior. These events do not occur only in the exact sciences, in the biology, in the natural sciences or in the technology, but also in economics (a stock market crash, a recession, for instance), in the law cases, in the social or single man behavior and so on.

The interest of the theory, therefore, lies in the wide range of cases where it is applicable; it evidently does not provide exact solutions in every case, but rather “models” which serve to clarify the “complexity” and how these phenomena are developed and because, suddenly, become “catastrophic”.

In the final analysis, the “catastrophe theory” can be considered as a branch of the theory of the dynamical systems and the term “catastrophe” here may mean a sudden change of the evolutionary structure of a system (that is, of its trajectory), in response to a small change in the parametric values that underlie it (that is, the external conditions).
In conclusion, the “catastrophe theory” can be configured as an innovative heuristic-hermeneutic structure or design platform for an “axial” age, that is one in which, as it has been repeated several times, the history changes trajectory, as it is possible neither the conservation, nor the increase, but is required a leap (of quality) with change of direction, that is a conversion, or a “catastrophe”, as it has been indicated in Figure 3, not for a “Conflict of Civilizations”, but for a “New Humanism”.

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Operational Transfer of Engineering Projects

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ABSTRACT

Let us consider an engineering work as any intervention, in any environment or system, that transforms it permanently or temporarily. Of course, there are many studies that tell if the project is viable, or that consolidate its planning. Nevertheless, at this point, we do not refer to them. Our focus is on the final stages, the transference of the product or service to its usage or operation. Hence, for the purpose of presenting the proposed thought, we shall consider that a work or a real estate project is divided into three stages: project, execution and operationalization.

*For the same reason aforementioned, the important stage called conclusion is omitted.

At each of the abovementioned stages, there are professionals with specific competencies involved. Architects and engineers prevail at the first stage. The same applies to the second, but with competencies different from those of the first stage. The execution stage is when the work is done. As for the third stage, the one in which the new system starts to operate, there is a wide range of professional competencies profiles, which vary according to the nature of the work or real estate project.

At this stage, even the users, who are normally laypersons, start performing and we must consider this fact of crucial importance in a judicious way. Civil construction has made progress when it comes to the third stage by establishing important norms for the operationalization of buildings. However, considerable gaps still remain.

Operationalization usually stands for putting into motion – or work –what “was on the drawing board” or on one’s mind. There is also, as mentioned before, a circumstance that tends not to be focused on, or is not addressed with the competency required and is in the root of the problem of processes operational transfer. It is the continuous functioning, the every-day running of the work or the system that has been implanted.
The interfaces among the stages of areal state project

By observing the interfaces among the stages of the work, it is possible to notice that, whereas the first stage, between both the architectural and engineering projects and the execution, is solidly constituted in methodological terms, the second interface, between execution and operationalization, does not show the same level of maturation.

All the work done in centuries, including IT, industrial production and any other types of projects, has made know-how transfer, communication and the language between architectural and engineering projects and their execution a mature activity. This activity is consolidated within good practices, technically defined and almost totally normalized.

Nevertheless, the interface between execution and operationalization does not show the same level of maturity. At this stage, still in process of maturation – with due regard for some exceptions – the case is not executing or installing what has been projected by engineering. It is rather putting into work what the Project has delivered.

The main causes of this maturity deficit of the operational projects transfer, which is responsible for financial losses, and other losses such as rework, guarantee and image, not to mention high risks, ought to be dealt with properly. According to our perspective, they may be listed as follows:

1st Communication failures
2nd Lack of knowledge on what the processes and their dimensions are
3rd Incipient standardization management practices

1st Communication failures

Let us picture a situation in which electric or telecommunications engineers have developed a new intelligent control system in an industrial unit. They will define the system they have conceived, as well as transmit it, so it can be implanted. That will be done by means of drawings, plans, memorials, specifications and manuals.

Engineers and analysts will perform everything in accordance to the technical documentation and the instructions received. However, during the startup and operationalization, the routine system running will be done by operators and technicians who tend to make errors, until they master the new configuration of the process, due to lack of standard procedures adapted to them. It happens even with groups of operators who receive specific training.

The documents handed by the technology professionals may frequently suit the rules of the language they share as a nation, but not the criteria of language understood as a communication tool. The former is a set of words and expressions of the citizens within a country. But it is the latter that allows people to deeply exercise communication, and employs much more than a national linguistic system. Two examples of what we intend to highlight regarding these communication failures are specifications and pictorial language.
Specification is a formal definition of characteristics and conditions that must be met by the products or services provided, regardless of their type, nature or state. A specification describes what should be done, and not how it should be done. Specifications are the basis of the contractual conditions between client and provider. A currently applied way of classifying specifications is the one that considers two different types: open and closed specifications.

According with wikihow (August 2016), an open specification describes demanded performances without informing how these performances should be achieved. It gives considerable flexibility to the entity that creates a product or assembly to meet the specifications. For instance, a specification for computer data storage may not specify the precise way of storing the data in order to meet the requirements.

As for a close specification, not only does it describe the performance required, but also the tools, technologies or subassemblies that must be used for designing a product or assembly to meet the specification. For example, specifications for an elevator assembly may demand the hydraulic energy used by the product or assembly to follow the specification.


There are other ways of classifying specifications, such as: specifications of project, product, process, maintenance etc. What we aim at highlighting is that, if there is huge difference between open and closed specifications, the differences between specifications and operational definitions are even huger. It is up to the last two ones guiding the management, the supervision and the execution of the operational processes that follow installation and assembly.

A second element to be taken into account is the visual language, that is, the language based on images.

![Diagram showing the relationship between Project and Operation specifications](image)

It is recognized that, in some cases, the operational procedures must make use of images as a great aid in communication.
Thus, for instance, in case an operational procedure is meant to refer to an upper limit of 20cc for a certain substance, the picture provides a clear and profound impression to the perception of the one who is supposed to perform the task.

While in a specification the written language is generally the most important one, operational procedures and definitions, especially in cases in which their usage will happen in environmentally aggressive conditions (excessive noise, bad weather, dust and others), the ease of the pictorial language should be considered.

2nd Lack of knowledge on what the processes and their dimensions are

Every work done in an organization is carried out by means of processes. These may be seen as a set of tasks whose result is a product or service. It is suitable then managing, supervising and operationalizing the processes. Engineering, IT and strategy generate new processes or change the current ones. Thus, at the end, there will be new or modified tasks to be performed, and certainly the product or service will be, as expected after these technological – or even structural or organizational – interventions, modified in their characteristics.

Although the process management knowledge and methods have evolved considerably, in general, they are still concentrated at the technological and managerial stages, without complementation at the operational levels of supervision and execution. It is necessary to promote advancements also in the operational approaches, developing criteria and methods adapted to the specific requirements of the daily routine. A first step towards that is the knowledge of what a process stands for. There are three basic definitions:

- Process as transformation
- Process as effects generation (products, services and results) and
- Process as a set of tasks.
Process as transformation: a process is a transformation of input resources into products or services, as well as results.

This definition allows us to focus on the inputs (INPUT RESOURCES) and the outputs (PRODUCTS AND SERVICES – AND RESULTS), leaving the analysis of the processing elements to the second definition of process. The operational transfer of engineering projects must identify accurately the requirements provided by the project, and make sure they will be met by the input resources, the products and services, and also the processing.

Furthermore, it is necessary to examine the whole set of legal, social and normative requirements that affect the operation and have not been spotted by the project, assuring that they will be taken into consideration by the operational plans.

Process as effects generation (products, services and results):

This definition focuses on the inner part of the process and on the necessary and total correlation that must exist between such part and the intended effects: a process is an organizational action that employs processing resources to meet the needs and requirements of the parties concerned.

Staff: refers to those who execute, that is, the operators that take part in the process.

Machinery: comprises all the mechanical, electrics and electronic apparatus and the utilities – including specific civil installations – applied to the transformation process.
Environment: the environment resource is divided into two approaches: type and disposal of the furniture, computer etc., and the environmental conditions themselves: temperature, lighting, and even interpersonal relations.

Items: these are the resources received from suppliers and that, once applied to the processing, enable intermediate or final products and services.

Methods: the methods for carrying out the work, that is, the ways or procedures for putting the project into practice and enabling the products or services. They represent a pivotal interface to the Project transfer, without minimizing the importance of the other phases, after all, even the personnel training may be compromised.

Measurements: gather the methods and equipment employed in order to determine if the processing and the product or service are being executed as expected in reference to the requirements.

Process as a set of rules: according to conventions, a process is said to be a set of rules constituted by the steps that one or more executors, in each task, must take in sequence, so that the work will be done.

Although each of the definitions has a specific meaning, when they are observed in a context of operational transfer of a Project, it seems right to consider them as a whole and look at them through three perspectives or more, specifically in accordance to what we name: Planning Dimensions and Process Operation.

Managerial dimension of the process planning and operation

The management dimension reflects the process management, which is the planning and disposal of the six resources of the planning, previously shown: staff, machinery, environment, items, methods and measurements. This dimension activates the other two, so that the process planning will be executed. It is up to the managerial dimension disposing everything that is necessary and make it all work as usual.

Technological dimension of the process planning and operation

This dimension is responsible for turning all the Project requirements, as well as the requirements of the
parties concerned that may not be identified by the project, into operational and standard definitions. In order to do so, the technological dimension makes use of engineering and, in some cases, administration techniques. At the end, it delivers this planning to the management dimension. The operational definition is the final stage of this entire logical unfolding, as shown below.

DEFINIÇÕES OPERACIONAIS: O SUPERVISOR a dimensão supervisional na empresa - Editora PUBLIT (Fonte: Juran Planejando para a qualidade Editora Pioneira, 1990, p.79 e p.117)

<table>
<thead>
<tr>
<th>Needs</th>
<th>Translation</th>
<th>Unit of measurement (Metric or indicator)</th>
<th>Data source for measurement</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guarantee duration</td>
<td>Guarantee duration</td>
<td>Months</td>
<td>Data system</td>
<td>X months</td>
</tr>
<tr>
<td>Coverage extensions</td>
<td>Number of covered or excluded subsystems; amount of covered or excluded costs</td>
<td>List</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>Distance covered by amount of fuel</td>
<td>Kilometers per liter</td>
<td>Odometer / fuel meter</td>
<td>X km / liter</td>
</tr>
<tr>
<td>Reliability</td>
<td>Reliability (absence of flaws)</td>
<td>Flaws rate (average time between flaws)</td>
<td>Data system</td>
<td>X hours</td>
</tr>
<tr>
<td>Punctuality</td>
<td>Frequency of deadlines not met</td>
<td>Data system</td>
<td>X %</td>
<td></td>
</tr>
<tr>
<td>Competency</td>
<td>Percentage of repeated calls for service</td>
<td>Data system</td>
<td>X %</td>
<td></td>
</tr>
<tr>
<td>Adequate technical assistance</td>
<td>Frequency of complaint about lack of courtesy</td>
<td>Data system</td>
<td>X %</td>
<td></td>
</tr>
</tbody>
</table>

3rd Incipient standardization management practices

Processes can also be defined as sets of resources that cause effects, which are the products and services produced by the processes. These resources are the various items that will be employed during
the processing, the machinery, the members of staff, the work environment, the tasks performing methods and the range of measurements related to the operations and the products and services of the process.

The projects, systems and interventions have direct impact over these resources. It is then necessary to operationally define, free from ambiguities, the new states. The standardization function must take care of the elaboration and control of these new standards. For their turn, the standards must turn the technical language into operational language. The set of operational definitions must be registered as standards.

A standard is a rule or example that provides, in permanent bases, clear goals and guidance.

Standards are a vital resource of delegation and execution. There are different types of standards. Some of them are meant to management use, while others are to be employed by the supervisor and the executors.

<table>
<thead>
<tr>
<th>TYPE STANDARD</th>
<th>OF ACRONYM (in Portuguese)</th>
<th>ISSUING</th>
<th>APPLICATION</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLITICS</td>
<td>POL</td>
<td>Board of directors</td>
<td>Board of directors of directors</td>
<td>Establishes formal declaration of positioning and guiding of an area of superior authority on a certain subject.</td>
</tr>
<tr>
<td>PROCESS STANDARD</td>
<td>PPR</td>
<td>Managers</td>
<td>Managers</td>
<td>Defines, to a certain process: parties concerned, requirements, operational definitions, tasks, responsibilities and authorities, interactions with other processes and, eventually, flowchart.</td>
</tr>
<tr>
<td>OPERATIONAL PROCEDURE</td>
<td>PRO</td>
<td>Managers</td>
<td>Supervisors</td>
<td>Work procedure related to a task, defining the best and safest method to perform it.</td>
</tr>
<tr>
<td>PROCESS MANUAL</td>
<td>MPR</td>
<td>Managers</td>
<td>Supervisors</td>
<td>Define, to a certain process, everyone's development and competency actions, including training additional descriptions of the process.</td>
</tr>
</tbody>
</table>

TIPOS DE PADRÕES - O SUPERVISOR a dimensão supervisional na empresa - Editora PUBLIT

In the managerial dimension, the standardization will elaborate, formally issue and communicate the standards. From that point, the supervision dimension will be responsible assuring that the standards will be employed and met, until they are improved.
4th Lack of knowledge about the supervision role

The new process specified by technology must be standardized, as previously exposed, by the management, and operationalized in a controlled way by supervision and operation. There emerges a great obstacle which is the natural tendency to lack of control and non-compliance of the standards.

“The essence of the organic function called supervision is to assure that everything will be done in the same way, every day, without unexpected situations, failures or accidents caused by execution deviations, having in mind what had been planned at the management level. While planning, testing and delegating the process operations are management attributions, the supervision challenge comprises putting the planned process into controlled operation, tested and approved by the management, and also make it routine as much as possible – between improvement gaps. Excellent high-level supervision is an art that demands competency, and which we can translate into process knowledge, experience, attitude coherent to needs, and the authentic leadership, as well as abilities related to methods and supervision techniques”.

Managers, operation leaders and supervisors have different attributions regarding the process, and the lack of understanding leads those who play these roles to working in a confusing way. Hence, it is not possible for them to achieve their best performance.

It is in the interface between management and supervision dimensions that takes place the delegation of the process operation. It is not possible to supervise properly without making clear which goals are to be achieved. That also applies to the work standards to be followed in order to achieve such goals.

The goals of supervision are different from those of the management and it is crucial to know the difference. Managers plan, project and implant the process operation. This implantation must be accomplished by delegating the process to the supervisors, who will be responsible for keeping the results of the process within the tolerance determined by the management. Hence, although supervisors also search for improvement, the main nature of their goals is predictability. As for the management goals, these are always linked to the improvement of the process performance.

Finally, there is a weakness associated to the role of supervision: even though the staff is the most important factor in the process, it is common to pay more attention and give more time to the other resources, especially machinery. It is the supervisor’s authority and responsibility educating, training, guiding, dealing with and motivating their staff in his authority ambit.

Final considerations

This paper presented points that are considered to be harmful to a correct transfer of a Project to operation. Both teams, which have clearly different professional profiles, ought to work together at this final stage of the Project, aiming at assuring that the requirements of the parties concerned will be consistently met since the beginning.
Bibliographical references


Sustainability Risk Management as a key factor on Corporate Projects

ABSTRACT

The concept of sustainability has grown in importance over the past two decades, with direct effects on corporate environment. In addition to economic and structural factors, other variables become part of corporate responsibility. So, in a scenario in which project management practices are becoming, in the same way, increasingly important, environmental issues must be taken into account as part of the risk management in order to ensure success and business longevity. Therefore, the purpose of this work is discuss, in the context of project management, the relationship between corporate sustainability issues and the risk management process as a key factor for contributing to a better planning and project success.

Keywords: Sustainability; Risks; Strategy; Project Management; Innovation.

1 INTRODUCTION

According to Cohen and Grahan (2002), nowadays project management is not just a technical process: it became a business process of critical significance. In order to get success on this challenge, it’s important that project managers, managers of project managers and members of the project team can develop a broader view of the company, with respect to internal and external factors to the organization.

In reference to external factors, Almeida (2007) says that society is demanding companies an attitude of greater accountability and transparency. In a market increasingly fierce, companies have sought better management practices to create a competitive advantage and meet the expectations of all stakeholders in your business, including issues focused on sustainability.

Veiga (2005) considers that concept of sustainability is a global imperative that is here to stay, because of the perception that the biosphere, at the global, regional, national and local environments, are being subjected to unbearable and damaging pressures to the own development and living conditions. Such pressures have caused changes on many companies, with consequences over different kinds of aspects related to corporate responsibility, beyond not just economic and structural issues.

In this scenario where risks associated with sustainability emerge as new elements on corporate environment, business managers find themselves faced with the challenge to continually monitor environmental issues in their activities, expanding its risk management and creating new business models that can draw on sustainability as value-generator for its investors.
Both sustainability challenge and project management best practices have many points in common. According to Marcelino-Sádaba et al (2015), project management is an opportunity to introduce sustainability in the organization, but it is an area not so explored and developed.

It’s also possible to note, as stated by Nidumolu et al (2009), that sustainability is a rich lode of organizational and technological innovations capable of generating as much profit as revenue, and the risks associated with this new scenario are the beginning to transform the competitive environment, forcing companies to regard otherwise products, technologies, processes and business models. As a result, managers and members of the business project teams must rethink their project risk management and its impacts on budget, communication, schedule and quality of their projects.

From this approach, the purpose of this paper is to discuss that the combination of project management and the challenge of sustainability has the opportunity to minimize these risks and maximize business opportunities for organizations.

Two authors were the main base of this research. The first is Dan R. Anderson, Emeritus Leslie P. Schultz Professor of Risk Management and Insurance, Department of Risk and Insurance at the Wisconsin School of Business and Emeritus Professor, Nelson Institute for Environment Studies, University of Wisconsin-Madison. His research involving risk management and sustainability looks at the risk not only as a threat but as an opportunity for business, opening doors for organizations become themselves competitive and, in this way, achieve new market positioning. The second author is Stuart L. Hart, Samuel C. Johnson Chair in Sustainable Global Enterprise and Professor of Management at Cornell University’s Johnson School of Management. Since 1997, with the revolutionary article “Beyond Greening: Strategies for a Sustainable World” he has been arguing that sustainable development will be one of the greatest opportunities in the history of commerce. Both concepts were joined in this research in order to achieve the goal of proposing a new vision for risk management under the scope of sustainability.

2 KNOWLEDGE AREAS FOR SUSTAINABILITY PROJECT MANAGEMENT

The concept of the “triple bottom line” was developed by Elkington (1997) and has established itself as a guiding element of many corporate strategies worldwide. He stated that the future market success depends on the ability of an individual company to achieve simultaneously not only the traditional pillar of profitability and economic prosperity, but also two new pillars: environmental quality (environmental protection) and social justice. Thus, organizations should develop their business strategies respecting these three dimensions and, in this way, promote sustainable development.

This concept covers a whole set of values, goals and processes that any company should focus in order to create economic, social and environmental value, and minimize resulting damages from this work, including all effects over project management processes, as illustrated on Figure 1.
According to Figure 1, the social dimension is focused on social sustainability, where the organization should chase the corporate social responsibility. Instituto Ethos (2009) defines corporate social responsibility as a form of management that relates company ethics and transparency with all its audiences, in addition to establishing business goals to boost the sustainable development of society, while preserving environmental and cultural resources for next generations, respecting diversity and promoting the reduction of social inequalities.

About economic dimension, the organization should aim to minimize all competitive pressures, maintaining the balance of the economy and taking into account ethical standards for the relationship between profitability and socially responsible behavior. The main challenge of the organizations in the economic dimension refers to the creation of sustainable value without sacrificing profit and shareholder value, as well as moral obligation versus growth opportunity.

The environmental dimension is related to the impacts on natural systems, including ecosystems, soil, air and water. Every socially responsible organization will seek to reduce negative impacts of their operations and maximize the positive impacts. An environmentally responsible organization must comply with environmental laws, the supervisory bodies and adopt management tools aimed at maximizing and environmental preservation.

For Project Management Institute, on its Project Management Book of Knowledge - PMBOK (PMI, 2013), projects can also have social, economic and environmental impacts with longer duration than the projects themselves. One of the areas covered by best practices in project management is risk management. In a corporate environment, according to the IBGC (2008), the enterprise risk management is a decision making tool for senior management that aims to improve the performance of the organization by identifying profit opportunities and mitigation of losses, going beyond compliance with regulatory requirements. Damodaran (2009) states that good risk management is at the heart of successful companies everywhere. With the addition of environmental sustainability as a component of corporate strategy, new elements emerge in this assessment.
Thus, an even more comprehensive risk management becomes important, to be able to predict not only economic, but also social and environmental, before, during and after completion of the projects. For the IBGC (2007), the implementation of enterprise risk management brings many benefits to the organization, including the preservation and increase of the organization’s value, greater transparency promotion to inform investors and the general public (stakeholders) the risks that affect the organization, and improves governance standards through the explanation of the risk profile adopted.

Mulcahy (2003) says that the process of risk management in projects is a systematic and proactive approach to have the project control and reduce uncertainty. This involves minimizing the adverse consequences and maximize the result of positive events. In this way, risks can be good or bad. When looking at the risk not only as a threat, but also as an opportunity, an aspect to be considered is the role that risk management plays at innovation process.

3 WAY TO INNOVATION

Bonini and Swartz (2014) consider that stronger goals seem to encourage innovation; people may feel more motivated to find ways to meet them. On the other hand, lack of goals is a sustainability killer on corporate environments. Important to note that the connection between sustainability risk management and innovation process can be supported by the development of a product or the corporate strategic processes. When understanding implications of global trends associated to sustainability issues and its connection with risk management, it can be possible to catch a glimpse of competitive approach towards the marketplace.

Talking about global trends, nowadays the world lives the phenomenon of global value chains, whose essence is to change the geographical distribution of design, production, distribution and consumption of goods and services. Increasingly these processes take place through a transaction flow that crosses boundaries and runs complex web of interconnected operations. Considering this model, Borini (2015) says that many companies have installed subsidiaries in several different countries, some emerging or underdeveloped ones. Reverse innovation is that one that comes from these remote points and are transferred to corporate headquarters. Thus, these value chain points become centers of innovation, breaking paradigms.

Amini and Bienstock (2014) identify innovation as a key factor both in terms of business success and for introducing sustainability management processes by going to the strategic objectives and decision making process. Therefore, it can be considered both Fernandez-Sanchez and Rodríguez-López (2010) approach, which propose the classification of risks and opportunities for projects in relation to sustainability through project management tools, seeking to reflect sustainable development goals based on the focus of the Elkington’s “Triple Bottom Line”, looking at the entire project life cycle.

As considered by Bonini and Swartz (2014), an emphasis on sustainability can also reveal opportunities for process innovations. By its crossfunctional nature, sustainability brings different divisions together and provides a common motivation; the result can be new, profitable ideas. So, sustainability may be on the spotlight or act in parallel with the core project objectives, specially when associated with the risk management process.
According to Buehler et al (2008), companies that have embraced the strategic risk management are the most successful ones. Larkin (2003) states that risk understanding and its effective communication can help on reducing conflicts and get support and trust - all essential attributes in obtaining and maintaining customers, investors and employee loyalty.

That’s the result of 2011 Mckinsey&Company survey, as presented by Bonini and Gorner (2011), in which finds that a handful of companies are capturing significant value by systematically pursuing the opportunities sustainability offers. The trend seems to be clear: more businesses will have to take a long-term strategic view of sustainability and build it into the key value creation levers that drive returns on capital, growth, and risk management, as show on Figure 2.

Innovation is the key, says Anderson (2005). The author believes that innovation related to the field of risk management has the opportunity to respond to these fundamental changes with solutions to the business world. In this way, this study brought together sustainability risk management aspects that can be addressed on corporate projects in order to provide, in an innovative approach, better results for the companies. In Figure 2 it’s possible to note how risk management, as considered by Anderson, is integrated to other processes: company growth (which delivers innovation as a result) and return of capital.

*Figure 2 – Capturing value in three key areas (Source: Bonini and Gorner, 2011)*
4 SUSTAINABILITY AND ITS ASSOCIATED RISKS

Project, as defined by Project Management Institute (2013), is a temporary endeavor undertaken to create a unique product, service or result. In this study, environmental and social sustainability issues are not necessarily the result of a project. This study proposes that, whatever the nature of the project, sustainability must be evaluated from the perspective of risk management and, if applicable, be addressed in order to add value to company.

Thus, Anderson (2005) states that risk management in sustainability is part of the overall concept of sustainable development. In the same line as the “triple bottom line”, the idea is that social justice and environmental responsibility are important issues in the risk analysis of organizations, with direct consequences on economic aspects. The author says it is increasingly clear that the risks related to sustainability have increasing impacts on businesses and organizations. These risks were listed by the author, as follows.

4.1 Boycott / Reputation

For Greenpeace (2007), companies that do not value actions that address social and environmental issues or have projects or practices that negatively contribute to the climate risks are subject to public campaigns that can hurt your reputation. Eccles et al (2007) point out that the reputation of a company is a function of its reputation among its various stakeholders - investors, customers, suppliers, employees, regulators, politicians, NGOs, communities in which the firm operates - in specific categories - quality product offering, corporate governance, relationship with employees, customer service, intellectual capital, financial performance, handling environmental issues.

Larkin (2003) argues that threats to reputation - whether real or perceived - can destroy literally in hours or days, an image or brand that has been developed and in which it has invested for decades. These threats should be anticipated, understood and organizations must plan for this through proper risk management. Anderson (2005) reiterates that this kind of risk may be the greatest sustainability one faced by most companies. The author sustains that reputation damage usually is a boost to competitors creating a competitive advantage.

In Brazil, the recent case involving a dam mud leak on Mariana city, Minas Gerais is a sample for this kind of risk (Portal G1, 2016). Companies involved - Samarco, Vale do Rio Doce and BHP Biliton - have been trying to rebuild their reputation, extremely affected by this environmental tragedy. Anticipate these risks in a effective way is a critical part of managing sustainability risks and can ensure legitimacy to the company.

4.2 Directors and managers

Pressure for good corporate governance and laws, such as Sarbanes-Oxley, has guided best management practices in companies. For this reason, managers and directors must be sure that internal controls are being met, under penalty of being held criminally liable for some inappropriate actions. A new world order pressure for corporations to become more transparent, making it difficult to obscure negative ac-
tivities. Esty and Winston (2008) argue that Sarbanes-Oxley will likely require that companies disclose more about environmental risks than they did before and presidents of the companies are responsible for knowing these risks. Anderson (2005) states that the company must identify environmental risks that could have a material adverse impact on achieving its financial and operational goals, and devote time and appropriate actions to control and fund these risks in their projects.

4.3 Damage to the ecosystem

The ecosystem where the company operates can also be affected by activities that are not aligned with the sustainability dimension, from indiscriminate use of natural resources to waste dumping without proper treatment. These kind of risk must be considered on organization assessment and may involve a great number of stakeholders. This is the reason for regulatory control increasing related to resource extraction and waste dumping on the communities where the company operates. From the detection of this risk comes an opportunity to start side projects in which affected stakeholders can receive company support and, on the other hand, be a partner on project success.

4.4 Regulatory Compliance

The enterprise risk management becomes the adjustment of the organization to legal and regulatory requirements easier, something critical to their survival (Anderson, 2005). For Nidumolu et al (2009), companies must face the respect for the rules as an opportunity for innovation, through ability to predict and influence regulations. Greenpeace (2007) warns that various regulatory scenarios have been introduced in response to climate change, which is reason for mapping these risks in corporate projects. Brazilian Planning Ministry (2013), on its Risk Management Guide to Public Administration, give awareness about external risks, including regulatory compliance (emergence of new laws, changes in regulation) considering health, security and, of course, environment, among others.

Another example of this concept refers to product manufacturers. They need to pay attention to systems such as Design for Environment (DfE) and Life Cycle Assessment (LCA), processes that emphasize examining the entire product cycle from raw materials through its disposal. This effort to design products to minimize environmental damages has been a legal requirement on some european countries (European Comission, 2016). EU legislation restricting the use of hazardous substances in electrical and electronic equipment (RoHS Directive 2002/95/EC) entered into force in February, 2003.

4.5 Pressure from investors

According to BM&FBovespa (2016), there´s a global trend of investors searching for companies that are socially responsible, sustainable and profitable in order to invest their funds. Such applications, called “socially responsible investment” (SRI), take into account that sustainable companies add shareholder value in the long run, because they are more prepared to face economic, social and environmental risks under a corporate governance practice. And it´s not just a situation verified on developed countries, but is really a trend among emerging markets. Marritt-Alers and Giese (2013) found that a growing number of investors are asking about corporate responsibility and sustainability in these parts of the world. In addition to investor interest, stakeholders ranging from emerging market governments to local and global
NGOs are raising awareness for the need to apply sustainability practices to the operations of companies in emerging markets. By this reality, it’s possible to verify that risks associated with sustainability are elements that influence the stock market and has been the subject of concern of responsible investors. Anderson (2005) states that there may be drop in the stock options value of companies that have an environmental incident or were involved in some kind of a scandal related to social justice. In that cases, investors predict future losses, anticipate possible legal liabilities, revenue decline, company’s reputation loss and co-responsibility for directors and organization managers.

4.6 Credit / Financing

Greenpeace (2007) warns that companies that fail to address the sustainability risk management in its activities may find difficulties on getting funding for their projects. More than fifty banks around the world, including Brazilian financial institutions, signed the “Equator Principles”, which are minimum criteria for credit granting by financial institutions, ensuring that financed projects are developed in a social and environmental responsibility. This means that environmental aspects have been part of the credit risk assessment on projects. Sustainable companies tend to become easier getting credit from financial institutions.

4.7 Relationship / Value Chain

This kind of risk creates a link to the entire value chain of a company and social and environmental issues. Nidumolu et al (2009) advocate the need for increasing efficiency on value chain, through the ability to ensure that suppliers and contractors, and other stakeholders, can be aligned with the organization’s sustainability strategy. During project acquisitions, mapping this risk is a critical activity, which can also leverage innovations and parallel projects with value chain partners. There are cases where outsourcing partners that do not meet labor rights with its employees. This responsibility is associated to contracting company, which shall bear the consequences of these mistakes.

4.8 Operational

According to Anderson (2006), global warming may be a significant risk factor regarding to climate change on many parts of the world. This subject has caused great concern among CEOs around the world, who increasingly seek to quantify, in a clear way, how weather can affect your company. There is an imperative need to understand what are the risks involved in a project and what kind of guarantee companies must have to keep their operations in the future. On the same way, cultural, ethical and regional disparity risks must be address by companies in order to foresee impacts on their activities.

4.9 Business opportunities / Competitive Advantage

For Hart (2006), competitive advantage was largely based on cost reduction or on obtaining differentiation in existing segments and businesses. Nowadays, it seems that it will depend on the capacity to generate innovation through competitive imagination. Kim and Mauborgne (2005) believe that new markets will be created through innovation and should follow a strategy to maximize opportunities and min-
imize the risks, but never take risks in a blind way. These are main sustainability risks listed by Anderson (2005), but not the only ones. Risks associated to insurance, crops, genetic modification and some others are listed by the author, but this study focused on the issues above.

5 THE PRECAUTIONARY PRINCIPLE

According to Schmidheiny (1992), scientific uncertainty about the issues involving climate change should not be used as an excuse for postponing actions to avoid environment degradation. A solution generally endorsed by governments and a growing number of companies is the adoption of “Precautionary Principle”. Incorporating caution through the Precautionary Principle, companies start initiatives to minimize any future damage, even without any certainty of its occurrence.

Precautionary ‘thinking’ has a much longer history, with known studies since 1854. But the Precautionary Principle, however, dates from the 1970s. As published by the United Nations Educational, Scientific and Cultural Organization on its report “The Precautionary Principle” (COMEST, 2005), some scholars mention a swedish and some a german origin of the Precautionary Principle. In Germany, the Precautionary Principle may be traced back to the first draft of a bill aimed at securing clean air. The law was passed in 1974 and covered all potential sources of air pollution, noise, vibrations and similar processes.

Under the perspective of sustainable development, Esty and Winston (2008) says that France constitution consider the right to a safe and healthy environment, and inserted the precautionary principle in its regulatory regime. When consider the risks involved in an environmental setting for the companies, caution appears to prevent the possible impact on business. But we should not discard the fact that we use caution also in our benefit, anticipating the negative scene through innovative solutions that can contribute to the company’s business. Risks can be mitigated, but generally are unpredictable.

The fact is that, as shown by Bonini and Bové (2014), among 13 core sustainability activities asked on a Mckinsey survey, executives most often say their companies are reducing energy use in operations (64 percent), reducing waste (63 percent), and managing their corporate reputations for sustainability (59 percent). These actions were cited most often in 2011 and 2012 previous surveys made by Mckinsey&Company, and a growing share of executives now identifies reputation management as a core activity. They are also most likely to say that among these activities, reputation management has the highest value-creation potential for their industries over the next five years.

Bonini and Bové (2014) continues, saying that there’s a lack of clarity around reputation management, compared with other, better-defined activities, such as reaching new markets with sustainable products. In this way, precautionary principle applying has been a important strategy.

6 SUSTAINABLE VALUE FRAMEWORK

Hart (2006) proposed a framework (Figure 3) in which a driver of sustainability - and its associated business strategies and practices - corresponds to a particular dimension of shareholder value. Thinking through the full range of challenges and opportunities is the first step managers can take toward the creation of sustainable value for the corporation.
The vertical axis in the model reflects the firms need to manage today’s business while simultaneously creating new technology and markets thinking about tomorrow’s scenario. This dimension captures the tension experienced by the need to realize short-term results while also generating expectations for future growth.

The horizontal axis reflects the firms need to grow and protect internal organizational skills and capabilities while simultaneously infusing the company with new perspectives and knowledge from the outside. This dimension reflects the tension experienced by the need to buffer the technical core so that it may operate without distraction, while at the same time remaining open to fresh perspectives and new, disruptive models and technologies.

Figure 3 – Sustainable Value Framework (Source: Hart, 2006)

Analysing the framework, the lower-left quadrant focuses on those aspects of performance that are primarily internal and near-term in nature: cost and risk reduction. Quarterly earnings growth and reduction in exposure to liabilities and other potential losses are important drivers of wealth creation. Clearly, unless the firm can operate efficiently and reduce its risk commensurate with returns, shareholder value will be eroded.

The lower-right quadrant also focuses on performance dimensions that are near-term in nature but extends to include salient stakeholders external to the firm suppliers and customers in the immediate value chain, as well as regulators, communities, NGOs, and the media. Without appropriate inclusion of these stakeholder interests, the firms right to operate may be called into question. Creative inclusion
of these stakeholder interests can foster a differentiated position for the firm, leading to the enhanced reputation and legitimacy crucial to the preservation and growth of shareholder value.

Shifting to the upper-left quadrant of the model, the firm must not only perform efficiently in today’s businesses but should also be constantly mindful of generating the products and services of the future. Internally, this means developing or acquiring the skills, competencies, and technologies that reposition the firm for future growth. Without such a focus on innovation, it will be difficult for the firm to create the new product and service flow needed to ensure that it prospers well into the future. The creation of shareholder value thus depends upon the firms ability to creatively destroy its current capabilities in favour of the innovations of tomorrow.

Finally, the upper-right quadrant focuses on the external dimensions associated with future performance. Credible expectations for future growth are key to the generation of shareholder value; this depends upon the company ability to articulate a clear vision of what its future growth path will be. A convincing growth path requires either that the company offer new products to existing customers or tap into previously missed markets. The growth track provides guidance and direction for new technology and product development.

From this perspective, Hart (2006) advises that companies should have a good performance in all parts of this framework if they wish to continue to generate values for its shareholders. And considered the proposed discussion of this study - sustainability risk management, Hart Framework assembles initiatives in this way.

It should be noted that Maletic et al (2014) states that another feature that makes project management a good way to introduce sustainability in organizations is that all aspects required for the sustainability management arise from areas defined by the project management standards: stakeholders, processes, products / services and lessons learned, as distributed by Hart in his framework.

7 CREATING THE SUSTAINABILITY RISK MANAGEMENT FRAMEWORK

Hwang and Jian (2012) say that, today, project managers fulfil not only their traditional roles, but also must manage the project in order to address sustainable issues. Thus, considering the sustainability risks listed by Anderson, they were distributed on Hart’s sustainable value framework under a risk mitigation approach. The result is shown on Figure 4.
From the perspective of project management, the initiatives as shown in the lower left quadrant of Figure 4 deal with better process management and business systems. The main idea is short-term performance by reducing risks and immediate costs related to operation cycle after a project delivery, all the regulatory requirements associated to project activities and company itself, besides giving more transparency to processes by implementing a project governance. As examples, the implementation of an Environmental Management System, compliance with standards like ISO 14001 and Sarbanes-Oxley, creation of eco-efficiency indicators within projects, an effective stakeholder mapping and the development of internal policies for treatment and waste reduction associated to project activities.

On the lower right quadrant of Figure 4, the main point refers to reputation and legitimacy. If the project scope is a product development, actions must address product lifecycle management and related services - from production to disposal and external stakeholder management. Issues involved consider suppliers and customers in the immediate value chain, investors, project financing institutions, regulators, NGOs and media in general, Industry Ecology and corporate social responsibility. According to Achterkamp and Vos (2006), the stakeholders engagement is essential to ratify the meaning of a sustainable product or process in a specific project. When it comes to Industrial Ecology, Marcelino-Sádaba et al (2015) note that the Eco-Design and Life cycle assessment (LCA) has been included among the different approaches to responsible behaviour in organizations (especially in relation to industrial and engineering projects).

The upper left quadrant guides focus on innovation, aiming at future growth. The value creation for the organization’s shareholders, according to Hart (2006), depends on the company’s ability to creatively
destroy your current skills in favour of tomorrow’s innovations. Despite being also a risk management process, they can become great business opportunities. Some initiatives such as new technology and clean innovations can be used to review waste dumping without proper treatment, massive use of natural resources and, in addition, induce side projects. For this reason, the main driver on this quadrant is the development of solutions to mitigate damages to the ecosystem, including both environmental and social aspects.

Finally, the upper right quadrant refers to the vision for inclusive capitalism and sustainable development. The company focus here is setting its path route to the future, identifying new markets and creating what Kim and Maugborne (2005) call “blue oceans”. These authors advocate this concept for the new markets that are created by innovative companies that make the competition irrelevant through unexploited business strategies.

Considering this new framework, which associated Anderson (2005) and Hart (2006) concepts, the project manager can identify guidelines to mitigate sustainability risks in short, medium and long terms on all kind of projects, as it is commonly done on risk breakdown structures.

8 GETTING TO WORK ON SUSTAINABILITY RISK MANAGEMENT

The sustainability risk management framework shown on section 7 joined concepts from Anderson (2005) and Hart (2006). In some ways, it has common points with a SWOT matrix, widely used corporate strategy tool and acronym for strengths, weaknesses, opportunities and threats. Important to say that sustainability risk management framework aims to map internal and external factors that can address sustainable issues on corporate projects, addressing both opportunities and threats for companies.

Additionally, the original concept created by ELKINGTON (1997) can be clearly address through sustainability risk management framework. The traditional pillar of profitability and economic prosperity is maintained without, however, fail to consider environmental and social aspects. Both corporate social responsibility and environmental dimensions now give the necessary balance to business goals establishment on this framework. This new way of conceiving business strategy can open new possibilities of communication between the companies and its stakeholders, adding value to corporations projects.

As mentioned before, sustainability may be on the spotlight or act in parallel with the core project objectives. Projects involving sustainability issues as the main result become clearer the risk management process:

As an example for sustainability as a core objective, it’s important to refers to the United Nations Office for Project Services - UNOPS (2016), an operational arm of the United Nations, supporting the successful implementation of its partners’ peacebuilding, humanitarian and development projects around the world. Its performance involving water supply and sanitation in Uganda, survey and clearance of mines and explosive remnants of war on Afghanistan or support to indigenous peoples’ and community conserved areas and territories in Brazil show how projects can meet social and environmental in a direct way.
But the main application of this article and, consequently, the sustainability risk management framework, are projects in which social and environmental issues are not the core objective or result. So, project managers can address sustainability aiming corporate benefit, as shown in these examples:

- a company may consider a project for mapping responsible third-party suppliers. Caution and stakeholder evaluation is necessary on choosing corporate partners in this process, both on environmental and social aspects;

- an industry should consider all the impacts before, during and after its production phase - operational, damage to the ecosystem, reputation and credit risks, among others;

- a product project may regard a proper disposal of it at the end of its lifecycle. In this way, Marcelino-Sádaba et al (2014) consider life cycle assessment (LCA) one of the most used methods for evaluating a product's impact on the environment over its entire lifespan;

- a construction and installation of a building plant may consider sustainability aspects. Marcelino-Sádaba et al (2014) found that within project management, this issue has been more generally introduced, particularly in environmental aspects. On this kind of project, aspects of pollution or mobility may address sustainability issues in project benefit;

- a software development project may take into account less use of computer processing and the possibility of virtualization services as a way to energy efficiency;

- and projects in general, considering regulatory aspects that can protect company against legal charges.

Thus, side projects may arise from each new project, improving the company's reputation and increasing company revenue. Aid to affected minorities, pollution treatment on regions in which company operates or partnerships with non-governmental organizations that can bring benefits to all stakeholders involved are some of the possible actions. That's what PMI (2013) calls "stakeholder management".

As stated by PMI (2013), Project Stakeholder Management includes the processes required to identify people, groups or organizations that could impact or be impacted by the project, to analyze stakeholder expectations and their impact on the project, and to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution. Elkington (1997) identifies two types of stakeholder groups: primary, whose continued participation is vital to the survival of the company; and the secondary, which influence or affect the company, and are influenced by it, but are not engaged in transactions with this company and are not essential to their survival.

In this way, stakeholder management requires a plan and continuous communication and control processes. The identification and control can be applied in line to other different project management areas such as procurement, cost and human resources, giving to risk management a comprehensive approach. Esty and Winston (2008) draw the attention to a case involving a famous french brand of natural bottled mineral water. In attempt to keep its pure water process and anticipating future risks, the company sub-
sidizes reforestation of watersheds and pays farmers that perform their activities next to water sources to embrace organic farming. That’s a good example of mitigating risks by identifying the right stakeholders.

Another important tool for risk management is the Risk Breakdown Structure (RBS). PMI (2013) says that RBS helps the project team to look at many sources from which project risk may arise in a risk identification exercise. Because of its dynamic concept, different RBS structures will be appropriate for different types of projects (PMI, 2013). When constructing the RBS with sustainable responsibility, innovation can emerge as a key for project success and company benefits. Sustainable risks can even be treated as parallel projects. It’s not the focus of this article go deep into this tool, but it’s important to indicate its relevance on this process.

On Project Management Offices (PMO’s) activities, project evaluation and selection may be sustainability driven, as a corporate strategy. This approach is addressed by Brook and Pagnanelli (2014), when they reinforce the importance of some aspects on project selection from the perspective of sustainability: strategic fit, brand position and reputation, customer orientation, market potential, profitability, emission reduction, leverage of technology capabilities and alliances enlargement. It can really be a driver for company innovation, even creating “blue oceans”, opportunities never before imagined by the company.

Brook and Pagnanelli (2014) additionally say that portfolio management as a innovation process has increasingly gained the attention of practitioners and academic during the last decade, but a limited insight has been provided into how to integrate sustainability into innovation portfolio management decision making process. That’s the opportunity project managers have to manage the sustainability driven innovation project portfolio through the strategic analysis phase to the monitoring of the portfolio performance during the development phase of the projects.

Finally, it’s important to state that sustainability risk management framework, as presented in this article, can be a driver to help project managers on planning, executing and closing their projects, that is, at all stages of the project. It is worth mentioning that managing risks is just possible with a close relationship to all other knowledge areas, as stated by PMBOK (PMI, 2013): Integration Management, Scope Management, Time Management, Cost Management, Quality Management, Human Resource Management, Communications Management, Project Procurement Management and Project Stakeholders Management. Each of these areas has processes that involves risks and, in many cases, can address sustainability risks.

9 CONCLUSIONS

This study was intended to bring the discussion of environmental sustainability for the corporate environment as a driver of business strategies from the view of the risk management. The authors mentioned here show that concepts like Corporate Sustainability and the “Triple Bottom-Line”, as well as new drivers for organizations, can open up a range of possibilities for business opportunities. The company market positioning in this new model requires understanding of the stakeholders needs, a universe of stakeholders ranging from the direct customer to the government, including employees, suppliers and investors, among many others. Dialogue with them, based on ethics and transparency, has raised gov-
ernance models that gradually are being absorbed by organizations around the world, in which project management best practices can help.

The article proposed an approach considering a more efficient risk management process, which can clearly identify the risks associated with environmental and social sustainability. But, most important, not only identify risks as a threat. A positive look at the risks can transform threats to opportunities. Generating shareholder value from the treatment of the sustainability risks, if well managed, may be a very interesting model to ensure the longevity of business enterprises. Innovation is the main word.

How article tried to expose, innovation can even emerge both from top down, as a strategy, and bottom up, as a reverse innovation. And the project managers can be leaders in this process. Stuart Hart’s sustainable value framework positioned in a very direct way the dimensions companies should address if they really want to create sustainable value for its investors. At this point, the concept of Dan Anderson about sustainability risk management was important because it enabled us to identify some of the main risks in this scenario. Joining both concepts, this research aimed to propose that sustainability risk management and sustainable value creation to the organization have a very close relationship. At the end, it was possible to address the original Elkington’s “triple bottomline” concept, in which economic, social and environmental aspects were considered on the sustainability risk management framework developed in this study.

It is important that organizations can understand that changes are inevitable from a new scenario in which risk treatment means business improvement. Ethical and moral values are part of the process when it comes to social justice and environmental responsibility. However, the study sought to show that these values begin to gain strategic relevance on corporate environments, and governance-based management models and transparency can bring results to business longevity.

Companies must choose and manage the right set of projects that match their sustainability agenda, based on the corporate innovation strategy. In an era where knowledge has been gaining ground and becoming the greatest value of a company, it’s time to innovate as project managers and, whenever possible, drive sustainability issues as an improvement of our work.

Finally, it can be observed that corporate world tends to surrender to that before might seem just a fad. It is important to companies follow sustainable practices in their daily projects, with risk management playing a crucial role.

But all this process is not a simple task. Companies need to ensure their own survival and business continuity can face a range of pressures coming from many different sides. So, this article had the purpose to put light on this subject, showing a wide range of opportunities that can be opened in the risk management area. Search for more innovative and sustainable initiatives inside companies is a key factor for projects success, reputation enhancement and profitability.
6 REFERENCES


Megaprojects Viability Studies: A Critical Analysis

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ABSTRACT

Recent research evidenced by practical examples shows that megaprojects often exceed the costs and deadlines, have unrealistic benefits forecasts and therefore fall far short of society expectations. The real cost of public ventures usually outweighs the costs estimated in the viability studies. In contrast, the benefits generally fall short of the initially estimated data. Gross errors in preliminary studies lead to misallocation of public resources and, consequently, cause serious damage to taxpayers. This article through literature review and a case study discusses the main causes of failures in the viability cost, timelines and benefits forecasts and presents mechanisms that can improve the quality of investment in large public infrastructure projects. Among the tools to improve the quality of forecasts, the article addresses a method called “Reference Class Forecasting”, which was recently developed from the theories of Daniel Kahneman, winner of the Nobel Prize in Economics, in 2002. In addition, it discusses the importance of continuous monitoring of cost-benefit rates over project implementation. It also presents a case study on West-East Integration Railroad (FIOL) in Brazil to illustrate the discussion. Lastly, the text suggests a new approach and provides a set of tools on how the audit courts can maximize efficiency on public megaprojects assessment, and thus, increase benefits to the society.

Keywords: viability studies, public works, public expenditure quality, megaprojects, cost-benefit
1 INTRODUCTION

Large infrastructure projects, also called megaprojects by the international literature (Flyvbjerg, 2014), generally have billionaire budgets and cause significant impact in society, in the environment and on public and private finances, therefore attracting political and media interest. However, such huge ventures implementation imposes challenges to politicians, planners and engineers, many of those obstacles related to the initial design and planning phases: viability and environment studies and initial designs.

Due to the magnitude and impact of such projects, there is relevant international research available. The Brazilian Federal Court of Audit, TCU – Tribunal de Contas da União have been pointing out problems in both initial designs and on viability studies. Flyvbjerg (2003, 2014) and Van Marrewijk et al. (2008) show that the costs and benefits estimates used as basis for the decision-making process on investments in large infrastructure projects are usually unrealistic.

In Brazil, there are plenty of examples that illustrate such budget overruns. The New Transnordestina Railroad construction, as a concession, is an example of a planning failure. The project was announced at the cost of R$ 4.5 billion and was expected to begin operating by 2010. Six years after the due date, just half of the work was completed, delivery was postponed to 2018 and estimated costs exceed R$ 11 billion. Another controversial venture is the construction of the Mane Garrincha Stadium in Brasilia which costs were estimated at R$ 750 million. In reality, the arena costs to taxpayers almost doubled, reaching R$ 1.4 billion. In fact, looking at all the 2014 World Cup Stadiums projected costs jumped from R$ 5 billion to more than R$ 8 billion. Moreover, there were not only budget overruns, but also benefits shortfalls. Some of these sports arenas are considered "white elephants", as the income they generate does not cover even maintenance costs. These facts, added to current resources shortage by Brazilian Federal Government, states and municipalities reinforce the idea that public spending on large projects need to be better planned, implemented, monitored and supervised.

Many projects have a poor economic and environmental performance. Costs overrun and revenue gaps challenge the feasibility and put the project at risk. Therefore, cost-benefit analysis, financial analysis and social and environmental impact reports are often refuted, questioned, criticized and denounced during the preparation of an infrastructure megaproject, more frequently than in any other field. Flyvbjerg (2003), point out that project promoters often violate practices of good governance, transparency and political and administrative participation, maybe due to honest mistakes or sometimes because some of these practices are necessary for a project get started.

The current paper was based in bibliographic research, and goes beyond comparing data presented on researches, reports and audits from TCU - as case studies. The originality of this paper and its main findings come from this empirical evidence for academic works about the inaccuracy and problems in feasibility studies of megaprojects, mainly on the infrastructure field. Besides this comparative analysis between audits data and international researches, this paper recommends innovative monitoring tools.

Considering this background, this article through literature review and a case study discusses the
main causes of failures in the viability forecasts of costs, timelines and benefits. As possible improvements to the process, it presents mechanisms that can improve the quality of investment in large public infrastructure projects. Among the tools to improve the quality of forecasts, the article addresses a method called “Reference Class Forecasting”, which was recently developed based on the theories of Daniel Kahneman, winner of the Nobel Prize in Economics, in 2002. In addition, it discusses ways to improve accountability and governance, highlighting the importance of continuous monitoring of cost-benefit rates over project implementation. Finally, the text suggests a new approach and provides a set of tools on how the audit courts can maximize efficiency on public megaprojects assessment, and thus, increase benefits to the society.

2 UNDERESTIMATED COSTS AND OPTIMISTIC BENEFITS: RANDOM OR INTENTIONAL ERRORS?

According to Van Marrewijk et al (2008) despite its growing popularity, megaprojects, in most cases, fail to meet the deadlines, the expected costs and benefits. Morris (1990) conducted the first empirical study focused on cost increases analysis and deadlines failures on large public projects. He concluded that the average percentage increase in costs was 82%.

The article “Cost underestimation in Public Works Projects: Error or Lie?”, written by Flyvbjerg, Holm and Buhl (2002), confronted cost forecasts and final costs of a large sample of transport infrastructure projects. In the study they analysed 258 projects representing a total of US 90 billion in investment. Final costs were accounted at the end of projects and estimated costs were taken from the decision making moment. All costs were calculated in the same currency using historical rates of exchange rates and other statistical evaluation mechanisms data. Their survey found that the cost forecasts used in the decision-making process regarding the implementation of projects were systematically underestimated. The analysis showed, with high statistical significance, that costs were underestimated by about 90% for transport infrastructure projects. The results showed that the final costs were higher than the estimated at the following rates: 45% estimated for railways, 34% for bridges and tunnels and 20% for highways. The underestimation of costs at the time of decision to build was noted in 20 countries spread across 5 continents. It is a global phenomenon. Based on these results, Flyvbjerg, Holm and Buhl (2002) concluded that the cost forecasts used in decision-making processes for the implementation of transport infrastructure projects are systematically misleading.

Similarly, it is the cost-benefit analysis, as they are based on cost estimates to calculate the viability and prioritize projects. That is, if studies costs are inaccurate, certainly the feasibility analysis will also be. Finally, the authors stressed that the findings could not be interpreted as an outbreak on public investment versus private investment in infrastructure, since the analysed data were insufficient to assess whether private projects had worse data or better than the public. They also warned that the findings were not restricted to investments in transportation, as other large projects were also sensitive to cost underestimation. In later studies, it was proved that these problems arise both in public and private sector and across industries.

Recently, the study “The diversion costs and execution time in public works in Portugal” (Costa, 2012) analysed financial data for 164 projects and time-interval data for 60 projects, ranging from 1999 to 2011. The main conclusions were that Portuguese public projects have underestimated their costs by 32% and
that execution time is double the allotted time. Although an econometric study has not been conducted, the survey found a correlation between election years (1999, 2002, 2005 and 2009) and the Portuguese public works cost increases.

3 UNDERSTANDING THE CAUSES OF FAILURES IN ESTIMATES

What are the real causes for so many distortions in the initial cost estimates of large-scale projects? There are several excuses to justify large project performance failures, such as “the unforeseen has happened”, “the project was very complex,” “the scope has changed”, “demand has not materialized,” “the economic environment was different,” “geological characteristics were found to be unfavorable”, among others. Undoubtedly these factors affect projects results, but they are not the root cause of so many estimates flaws. The root cause lies somewhere around not considering correctly these risks during the viability studies process.

According to Flyvbjerg et al (2011), the “technical” explanations claim that the lack of accuracy in estimates arise from the use of unreliable or outdated data, inappropriate forecasting models, as well as planners lack of experience of. However, if this was the real cause for errors, it would be expected a normal distribution of errors: some equivalence between under and overestimations, with a mistake average close to zero.

However, as shown by examples above, most of the time, cost and benefits forecasts are very optimistic, when compared to the final results, showing that accuracy is not the real problem. In addition, if the imperfection of data and models was the real problem, one would expect an improvement in accuracy over time due to the progress of the project management techniques, which was not noticed over a historic period of 70 years according to Flyvbjerg research. This indicates that factors besides poor data and incorrect models are really responsible for the failures of the cost and benefit estimates. According to Flyvbjerg, psychological theories and political-economical explanations can better describe the cost overruns and benefit shortfalls.

Psychological explanations relate errors in the cost-benefit estimates to the optimism bias. It is a cognitive bias which leads us to judge the impact of future events more favorably, positive, than proven by previous and current experiences. People, unintentionally, imagine success scenarios and underestimate the potential for errors. As a result, it becomes unlikely that projects are delivered on schedule and costs, or to provide the expected benefits. (Flyvbjerg, Holm and Buhl, 2002). The term planning fallacy for this effect was first proposed by Daniel Kahneman and Amos Tversky, Nobel winners for studying how psychological effects affect decision making.

Political explanations, on the other hand, justify the lack of accuracy, in terms of strategic bias, which can be described as a deliberately data misrepresentation. This occurs when planners and managers intentionally and strategically overstate the benefits and underestimate the costs order to increase the possibility of their projects getting approval or receiving resources. This explanatory model has been set forth by Flyvbjerg, Holm, and Buhl (2002, 2005) and Wachs (1989, 1990).

Bent Flyvbjerg, Professor at University of Oxford, in the article “Survival of the un-fittest: why the worst
“infrastructure gets built – and what we can do about it” (2009), states that planners deliberately extend the success scenarios and hide risks. In this context, if lie is defined as a statement made to deceive others, deliberate costs and benefits misrepresentation is a lie. According to this explanation, Flyvbjerg states that where there are political and organizational pressures, there is strategic misrepresentation.

In some cases, the strategic misrepresentation may be motivated by acts of corruption, fraud and bribe payments to public officials. According to the OECD, in the study “Bribery in Public Procurement Methods, Actors and Counter-Measures”, public contracts are developed through a complex and long process, that can take many years, going through many stages from conception, design until implementation. Bribery can occur at any stage along the way, from the initial steps to the process of hiring and execution (OECD, 2007). When bribery occurs at early stages, investing decisions have an apparent legitimate appearance, in spite of being deceived. Thus, due to corruption, many unviable works are implemented, regardless of the real public interest.

4 MECHANISMS TO IMPROVE THE QUALITY OF PUBLIC SPENDING

This section will discuss mechanisms that can be employed to improve the quality of decision-making on project investments. First, a method that improves the confidence of the investment forecasts for major projects, called “Reference Class Forecasting” will be addressed. Then we discuss the need for increased accountability, continuous monitoring of the project’s viability and the role of auditing and control.

4.1 Reference Class Forecasting

Based on the theories of decision making under uncertainty, Daniel Kahneman, Nobel Prize in Economics 2002, has recently developed a promising project management method aimed at minimizing the effects of the optimism bias and strategic misrepresentation, thus improving accuracy and reliability of the cost-benefit estimates used to assess the viability of projects. This method, called “Reference Class Forecasting” was endorsed by the American Planning Association and the UK Treasury.

The paper titled “From Nobel Prize to Project Management: Getting Risks Right” (Flyvbjerg, 2006) explains the main features of this method. The traditional way of thinking about a complex project is to focus on the project itself and its details (“insight”), in order to try to understand as much as possible about the project, its unique characteristic, as an attempt to predict future events that may influence results. But this costs and paybacks forecast is usually optimistic and can be misrepresented, as shown above.

In this sense, the method “Reference Class Forecasting” preaches a systematic analysis of planning based on an “outside view” of the problem. More specifically, the method requires the three following steps:

I. Identify previous similar projects (reference class). The set of information should be broad enough to be statistically significant.

II. Establish a probability distribution for the reference class selected to allow empirical findings.
III. Compare the design on screen with the probability distribution of the reference class in order to establish the most likely outcome for the specific project.

To simplify the understanding of the importance of “external view” to the project, here’s a hypothetical example. Based on project management scheduling tools, a certain large railway was planned to be built in two years with the cost of $“X” million/km. However, railways of this size were never built by the executing agency in less than six years and never costed less than $1.5 “X” million/km. If there has been no impressive technological revolution, which would lead one to believe that the current project will be so much more efficient than the previous ones?

Recently, the UK Department for Transport decided to apply the “Reference Class Forecasting” as part of the large transportation projects evaluation process. The first step was to collect data from the initial and final costs of hundreds of projects, separated into categories, with similar cost increases risks. For example, regarding railroad construction they collected data for 46 projects, establishing a class reference. These results were used to establish the distribution curve shown below (Flyvbjerg, 2006).

![Image](https://example.com/flyvbjerg.png)

**Figure 1** Probability distribution for cost increases in railways (Adapted from Flyvbjerg, 2006)

The cost increases distribution (Figure 1) shows that half of developments in the reference class “rail” in UK had cost increases of 40% compared to the originally planned budget. The other half exceeded in more than 40% of the initial forecasts. It is also noted that 80% of the railways were completed with cost increases of up to 60%, meaning that the remaining 20% of projects completed with cost increases of up to 60%.

Then, for viability studies and evaluation of budget availability purposes, the estimated project cost should be adjusted (increased), based on the probability distribution and the risk accepted by the entrepreneur. The degree of increase depends on the appetite for risk. The concept of risk appetite can be understood as the desire for someone to take risks versus the potential return. For an organiza-
tion (state or private) with a moderate risk appetite, or that is not willing to lose resources with any cost increases and/or declines in revenue, it is advisable to consider the safety range of 80% for their viability analyses. Thus, the probability of the estimated costs (set) to be exceeded over time is only 20%. Therefore, only 2 projects every 10 will cost more than the value considered at the time of decision making. But if the organization adopts the 50% range, it means that about 5 out of 10 projects executed will probably cost more than estimated at the time of feasibility analysis, which may imply that the invested “capital” may decrease, rather than increase, after project execution.

According to Flyvbjerg (2006), the UK Department for Transport has usually adopted a range of 80% security for adjustment of estimated project costs at the time of decision making for large investments in transportation infrastructure.

It is important to note that this method does not replace the traditional viability studies, much less the basic designs and executive projects, used to obtain analytical budgets with higher degree of accuracy. The method simply adds an experimental risk analysis in the early stages of decision making, when the degree of uncertainty is very large, in the same way engineers adopt a safety factor in structure calculations.

In short, this paper believes that one way to improve the initial estimates of cost-benefit of Brazilian infrastructure projects is to supplement traditional assessment with an empirical risk analysis based on past performance of similar projects (in the same category), as proposed by the “Reference Class Forecasting” method. Thus, cost and time estimates of a particular project should account for the history of similar past projects. This would measure whether a particular project is really viable, after costs are adjusted based on past experience of similar works.

4.2 Continuous Viability Monitoring

It is well known that risks and uncertainties are higher at the beginning of a project, decreasing as decisions are made and deliveries are accepted. On the other hand, the cost of changes and bug fixes generally increase expressively as the project is near to completion (Figure 2).
As shown in the figure above, the later a certain change in the planning is made, the more costly it will be. For example, when a large development is considered unfeasible in the preliminary studies (EVTEA), and therefore is aborted, losses are almost negligible, the only loss being the resources used in the preparation of the study. However, if a project is found out to be unfeasible during design stage, the losses rise slightly, due to the costs with field surveys and tests, but investment still remain low. If the project is considered feasible and is aborted after the start of construction due to the discovery of extra costs or even the decrease of the forecasted demands, costs capitalized will be exponentially greater. More significant is a case when the project is fully implemented and, after its completion, it is found out that its benefits do not even cover their costs. The worst situation occurs when inflows don’t pay even their maintenance costs, which lead to increasing losses over time. In these situations, investors and sponsors are negatively affected, as resources are exhausted down the drain. In the case of public enterprises, it means taxpayers taxes being wasted.

It is extremely important to keep record of previous decisions in order to learn from the mistakes and form the past.

In addition to learning from previous failures, it is possible to mitigate losses by continuously monitoring the evolution of the project. According to the PMBOK Guide, monitoring should be performed from start to project completion. Continuous monitoring enables a clear understanding of “health” project (PMI, 2014).

Given the above, this paper argues that a continuous monitoring of routine viability should be developed throughout the life cycle infrastructure projects. The viability analysis should not be scrutinized only during preliminary studies (in Brazil, called EVTEA Estudo de Viabilidade Técnica Econômica e Ambiental), but also during the following stages: basic design, executive project - at the beginning, during the construction, and at the end, which is not currently done. In addition, monitoring allows to evaluate the accuracy of forecasts and improve planning new projects.

Essentially, this continuous monitoring would mitigate investors losses and also make a continues assessment of whether the project should be kept unchanged, postponed to a more appropriate time, changed, or, in the last case, aborted, if costs hopelessly outweigh benefits.

5 CASE STUDY

Some recent studies of the Brazilian Federal Court of Accounts (TCU – Tribunal de Contas da União) advanced in assessing the viability of projects and investment programs. As a case study, this article presents an audit performed in 2005 at FIOL (Railroad East West Integration, executed by VALEC). During this audit, TCU evaluated issues concerning the viability of Railroad East West Integration, planned to link the cities of Ilhéus in Bahia to Figueirópolis in Tocantins. It found out that the assumptions made in the study that supported the decision to build the railway were not compatible with the current reality. The economic, technical and environmental feasibility study (EVTEA) did not properly assess the political, economic and financial risks involved in the implementation of the project. On the other side, the analysis showed an optimistic bias and various assumptions considered failed, such as the estimated delivery time. The following information was extracted from the audit report and vote accompanying Acórdão 2644/2015-TCU.
According to preliminary project studies, the 1500 km railroad should be operative by January 2015. However, in July of the same year, there was not a single operational kilometer and approximately a third of the railroad was not even tendered. At the time, the most optimistic expectations forecasted the completion of the first portion of the railroad, connecting the city of Caetité to Ilhéus” for the year 2018, while the viability studies stretched operation launch to 2013. For “Barreiras-Caetité” segment the situation was even more extreme, where several sections were not even designed or expropriated, even after constructions works were already undergoing.

It was noted, besides the existence of fictitious schedules, that iron ore, the main product to be transported by railroad, accounting for over 94% of the initial planned demand, was suffering a strong devaluation, which led to huge mining investment reductions, in the region. Consequently, there was a significant iron ore transport demand reduction, demand which was used as a major reasoning for the existence of the enterprise itself.

However, these and other changes in the feasibility study assumptions were not being monitored or treated by the government. As TCU auditors appreciated the scenario, the report pointed out it was not possible to ensure the viability of the railway maintenance or some of its parts. In other words, there was no real evidence that the benefits from the implementation of the railway outweighed its costs. Therefore, its implementation was at risk of causing a billionaire leak to the public funds. Considering the significant delays in delivery of the construction, the drop in the price of iron ore, increased interest rates and the resource contingency, TCU understood that it was necessary to assess the continued viability of the project. Consequently, recommended through Decision 2644/2015-Plenary, that the government should re-evaluate FIOL’s cost-effectiveness, considering at least four alternatives/ scenarios ranging from the partial accomplishment (operational sections) until the full accomplishment of the project. It also recommended conducting studies with the identification, evaluation and treatment of the enterprise risks and the establishment of monitoring mechanism of the benefits and rail costs.

6 CONCLUSION AND PROPOSALS

International literature and national practical examples show that the cost-benefit estimates used in the decision-making processes for large infrastructure projects investments are systematically misleading. Thus, routinely, the final cost significantly outweighs estimated costs in the viability studies, in contrast to the benefits that plummet, reducing the viability of enterprises.

Unlike the usual excuses, the real causes of project performance failures cannot be attributed to unforeseen events and honest mistakes, but the lack minimally consistent viability studies (cost-benefit), the non-identification and treatment of risk, the excess of optimism in planning and, more severely, strategic misrepresentation of information used to support the decision-making process for investing or not in a venture.

One way to improve the estimates is to account for the history of similar past projects, correcting,
when appropriate, budgets affected by the optimistic bias. The method prescribed in the “Reference Class Forecasting” suggests to supplement traditional data with an empirical risk analysis, taking into consideration similar projects past performance. A project would be considered viable if the benefits outweighed the corrected estimated costs.

Moreover, the cost-benefit ratio should be evaluated and audited not only at decision making (feasibility study) moment, but it also should be monitored throughout the whole project life cycle (preliminary studies, basic design, executive design, implementation and operation). Thus, stakeholders could better assess whether an enterprise should be kept unchanged, postponed or lastly aborted, if costs outweighed benefits irreversibly.

As suggested by Flyvbjerg (2014) this new methodology must be combined with better governance structures with incentives that reward accurate estimates of costs and benefits and punish inaccurate ones. The adoption of a robust institutional checks and balances system, including financial and even criminal penalties for rough estimation errors would certainly result in the production of more realistic cost estimates.

Finally, Federal Court of Audits can play an important role in promoting cultural change. It can analyse and monitor infrastructure projects viability, in order to encourage public managers to employ resources in a more rational and efficient way, minimizing the incidence of non-viable projects and therefore improving the quality of public spending.

7 REFERENCES
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Optimization of the Investment of a Large System / Plant, as a Balance between Reliability, Costs and Incomes

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ABSTRACT

This paper covers the optimization of the investment of a large system / plant, as a balance between reliability, life costs and incomes; it is the development at system level of a work presented at IX ICEC World Congress.

The general topics are:

- Relationships amongst the service supply, life cost and incomes.
- Plant alternatives, and the relevant costs.
- System reliability assessment, i.e. the outages frequency and duration, and their economic impact.
- Criteria for comparison of the alternatives, to reach a sound decision.

Some topics are also considered:

- Economic Impact of Common Cause Failures.
- Cost reduction with autodiagnostic.
- Impact of repair times
Keywords: Risk, Cost Optimization, Reliability

1. INTRODUCTION

The energy supply continuity has become one of the more relevant factors both in Industrialized and in Developing Countries; therefore, a suitable analysis is recommended to reach a sound compromise between service quality and cost.

The evaluation of industrial projects is usually carried out trying to reach an optimization / compromise between performance and what are considered overall costs along the project life; conversely, reliability aspects are often taken into account only once that the plant configuration and the budget have been decided, and this rarely leads to a sound optimization. In general, reliability and performance are considered as opposite to lower cost; the solution is to reach an optimization that can be:

- Maximum reliability at a prefixed cost, or
- Minimum cost at a prefixed reliability level

2. METHODOLOGY

The paper covers the reliability / cost analysis of a power station. The several steps of the analysis are as follows:

- Identification of the possible system alternatives
- Identification of the several states, relevant to the partial / total system out-of-service
- Reliability analysis by means of Markov processes in order to identify frequency and duration of the several system states (system outages), which correspond to the loss of produced energy
- Identification of coefficients for each state of loss of production, considering the individual importance of several states
- Cost evaluation of the loss of produced energy
- Discounted cash-flow analysis
- Topic: Common Cause Failures
- Topic: Autodiagnostic
- Topic: Long repair times

For sake of clarity, the above methodology is directly applied to a real case study.

3. PLANT CONFIGURATION ALTERNATIVES

The following example will be used to clarify the application of the above proposed methodology.

The First Step is the identification of the possible Plant Alternatives.

This analysis covers the comparison of three Combined Cycle (the gas turbine exhaust is used to produce
steam) Power Plant Configuration Alternatives A, B and C, referred to the following parameters:

- Power Plant probabilistic evaluation of the average power delivery,
- Quality of the power delivery, i.e., frequency and duration of the faulted conditions

Figure 1 – Power Plant Alternatives

**Configuration A:** Single Shaft Combined Cycle
2 Gas Turbines +2 Steam Turbines
(2 Generators, 2 Transformers)

**Configuration B:** Multi Shaft Combined Cycle
2 Gas Turbines +2 Steam Turbines
(4 Generators, 4 Transformers)
4. **CALCULATION METHOD**

The methodologies suitable for systems reliability analysis are:

- **Markov Process**: it is very effective to represent the fault-repair process, but it can be applied only to systems with few components; their limit is that with a certain quantity of components and transition possibilities the transition diagram would be too expanded;

- **Monte Carlo simulation**: it is very effective for complex systems, but the results interpretation could become problematic, due to the difficulty to trace the transition process.

In the case of a power station, the Markov process is the recommended choice, because the transition diagram is still within acceptable dimensions.

The Transition Diagram has to include:

- **Transition States**: Transient system configurations that take into account the up-down states of the components, their interactions, and specific failure-repair transitions

- **Residence States**: Cumulative states that include one or more of the above defined Transition States, with the same output parameter that is relevant for the reliability goal (e.g. the cumulative output power of a power station with many generating sets)

4. **PLANT OPERATING STATES**

The **Second Step** is the identification of the several operating states, and of the operating condition (power delivery) relevant to these states

The sequence is as follows:
• Definition “A Priori” of the Residence States of the repairable system

• Identification of the interdependencies and CCFs, and their Transition States included in the Residence States

• Ordering the Transition States: the ones relevant to CCFs are with progressive number after those without CCFs. There are two areas:
  ◦ An internal area, without CCFs
  ◦ A peripheral area, with CCFs

• Solution of the Transition Matrix by means of numerical methods.

The transition Diagram and Matrix relevant to Alternative A) are reported in Fig. 2 and 3; the whole set of transition diagrams, matrices and equations can be found in [17], available online at http://drum.lib.umd.edu/bitstream/handle/1903/11205/Guenzi_umd_0117E_11768.pdf?sequence=1&isAllowed=y.

**Fig. 2 – Alternative C) – Transition Diagram**
The Transition Matrix is leading to a linear system of equations, that can be solved by means of usual numerical methods.

**Step 3 – Reliability/Availability Assessment**

The main characteristic of a power station, relevant for a reliability/availability analysis, is that it is a set of generating units which can be out-of-service, either one by one, or more than one simultaneously. In this case, the reliability/availability analysis of the three alternatives has to take into account the following parameters, which represent the reliability/availability indices:
• **Average Power Delivery:** It is the weighed mean of the products of the power delivery of each generating state (Residence State), and the probability of the system to reside in this state, referred to the overall power plant capacity:

\[ PE = \left( \frac{\sum_{i=1}^{n} p_i P_i}{PT} \right) \times 100 \]  
(1)

where:

- **PE:** Average Power Delivery
- **PT:** Power Plant Rated Power (450 MW)
- **i:** Partial Production Generating States (150 MW, 300 MW, 225 MW, etc.)
- **Pi:** Probability of the system to reside in State i
- **pi:** Power Production at State i (150 MW, 300 MW, 225 MW, etc.)

The Pi probabilities are those included in the asymptotic transition matrix; they represent the asymptotic probabilities of the system to reside into the several states.

\[
\begin{bmatrix}
0 \\
0 \\
0 \\
1
\end{bmatrix}
= 
\begin{bmatrix}
- B_1 & \rho_{2,1} & \ldots & \ldots & \rho_{n,1} \\
\rho_{1,2} & - B_2 & \ldots & \ldots & \ldots \\
\ldots & \ldots & - B_i & \ldots & \ldots \\
\ldots & \ldots & \ldots & - B_i & \ldots \\
1 & 1 & 1 & 1 & 1
\end{bmatrix}
\begin{bmatrix}
P_1 \\
P_2 \\
\vdots \\
P_n
\end{bmatrix}
\]

where:

- **pij:** rate of departure from state “i” to state “j”

\[ B_i = \sum_{j=1, j \neq i}^{n} \rho_{i,j} \]

• **Frequency and Duration of System Residence into the “i” States:** This index represent the quality of the power delivery

5. **ENERGY PRODUCTION / POWER DELIVERY ADJUSTMENT**

This is the **Fourth Step** of the analysis.
The result of the above reliability evaluation is the power amount that can be generated and delivered to the grid; the product “power x time = energy” leads to the further “energy x KWh tariff = project economic income”.

However, for a sound project evaluation, it is advisable to consider also two different points of view:

- **Utility Point of View**: the Utility main interest is in energy selling, therefore the system performance index is simply the Project Economic Income = Energy x KWh Tariff. However, there are some constraints related with Industrialized/Developing Countries, Load Forecast and Power Station size, as reported in the following chapters.

- **Customer Point of View**: for the Customers, the main concern is to avoid as far as possible power outages; therefore, the several system “states” with less than the total possible power delivery have to be penalized.

Moreover, two different points of view relevant to the Customers have to be considered, in order to take into account the specific aspects of power delivery in Industrialized or Developing Countries, as follows.

- **Industrialized Countries**: Specific characteristics of these Countries are:
  - Load Forecast with a moderate per cent increase;
  - Consistent Generating Park, with a permanent reserve, suitable to promptly compensate a power station out-of-service.

The decision to install a new power station is often due to the necessity to substitute an old existing one; only in few cases it is necessary to install a new power station, to face the future load demand. Eventually,

- A new power station should be called to produce at full capacity just from its start-up. Therefore, the economic income is just the energy produced at the total capacity, possibly with a reasonable reserve margin;
- The partial or total out of service of the new power station is supposed to be easily compensated by the remaining generating park, and the penalization of the “states” with limited production can be either modest or null.

- **Developing Countries**: Specific characteristics of these Countries are:
  - Load Forecast with sometimes relevant per cent increase; in many cases, the Load Forecast is conditioned by the power availability, and it can increase with the addition of a new power station.
  - Limited Generating Park, with poor reserve; difficulty to promptly compensate a power station out-of-service, which can be dramatically sharpened in case that the faulted power station is the predominant one.

The decision to install a new power station is mainly due to the necessity to match the increasing Load Demand.
Eventually,

◊ A new power station is usually oversized for the present Load Demand, and it can be called to produce only at partial capacity along the first years. Therefore, the economic income is the cost of the energy produced at partial capacity, until the Load Demand is increased up to require the full power availability.

◊ The partial or total out of service of the new power station can be barely compensated by the remaining generating park, and the penalization of the “states” with limited production becomes quite relevant.

The project evaluation is usually carried out by means of the widely used DCF - Discounted Cash Flow technique; in this case, the DCF “income” is the energy selling, that has to be adapted in accordance with the above considerations.

Specifically:

◊ The system “states” with total or higher energy production have to be compared with the actual Load Demand; otherwise the DCF income would be not realistic. This comparison leads to quite negligible effects in Industrialized Countries, but relevant effects in Developing Countries.

◊ The system “states” with low or null production have to be “penalized”, due to the difficulties arising from the total or partial power outage; the penalization is low or negligible in Industrialized Countries, and it can be serious in Developing Countries.

The above mentioned penalization of every low production state of all the alternatives has to be computed as an yearly “outcome” Q in the Discounted Cash Flow; it has to be considered as an amount to be properly assessed on a case-by-case basis, taking into account the specific characteristics of the project, as above discussed.

This fixed amount has to be adjusted with the following figures / coefficients:

◊ L: Loss of produced energy; this is coming from the identification of states and their power production.

◊ C: Unit (KWh) Shadow Cost of the lost energy; this shadow cost (outcome) has to be assessed on a case-by-case basis, and it can be quite different from the unit cost (income) of the produced energy.

◊ K1: Coefficient that takes into account the difficulties for the power outage; this coefficient is much greater for Developing Countries that for Industrialized Countries. and especially in case that the power station in analysis is predominant.

◊ K2: Coefficient that takes into account the extension of a power outage; a general black-out is much worse than a localized outage. This coefficient is much higher for Developing Countries,
Finally, the penalization (yearly outcome) is:

\[ Q = L \times C \times K_1 \times K_2 \]

The above criteria is originated by a general system reliability rule: If the overall system is poor, the component reliability has to be strong.

6. FINAL ANALYSIS

This is the Fifth Step of the Analysis

The project evaluation can be properly carried out by means of DCF – Discounted Cash Flow technique.

Incomes
◊ Energy selling, properly evaluated and adjusted as described in the previous chapters.
◊ Residual value of the Plant

Outcomes
◊ Capital cost of the several alternatives.
◊ Penalization of the low power states, as described in the previous chapters.
◊ Operational costs of the Life Cycle.

Overall (very summarized) results:

Configuration B) proved to be the more reliable, although the difference with the other configurations was not high; conversely the cost of Configuration B) was higher.

However, Configuration B) has been chosen because it was the best compromise, taking into account that it had to be installed in a Developing Country, and it was the predominant Power Station, therefore the necessity to avoid as far as possible any outage was predominant.

Other aspects related to both reliability and costs, and included in the life Cycle, are:

◊ Preventive Maintenance;
◊ Corrective Maintenance;
◊ Spare Parts.

They will be treated in future papers.
7. TOPIC – CCF (COMMON CAUSE FAILURES)

A typical solution to improve system reliability is the use of sub-system / component redundancy; in fact, this is a good practice, but it is entailing additional costs.

A typical problem with the redundancies is the occurrence of CCFs (Common Cause Failures) which can decrease so much the impact of the redundancies.

In simple words, a CCF is such an additional component in series with the redundant ones; in most cases, this fictitious additional component can become predominant and neutralise the impact of component redundancies. In terms of economics, the benefit of the additional cost of the redundancies is frustrated by the impact of the CCF.

Typical CCFs are:

◊ Common Auxiliary Systems, shared by the redundant components; e.g. a common water cooling system for two redundant motors / compressors.
◊ Design Limit of the redundant components; e.g. the undersizing of redundant emergency lube oil pumps leads to the sequential out of service of both pumps (it really happened to the Authors called to start up a Power Plant that during a shut down a lube pump became overloaded and had to be disconnected; the redundant one of course suffered the same problem and a serious situation had to be faced). The Design Limit is a typical attitude of some designers, that, once accepted the additional cost of a redundancy, want to limit as far as possible the cost of the individual components.

Therefore, a comprehensive CCF analysis is highly recommended, in order to avoid frustrating the high cost of the redundancies.

A suitable methodology has been developed by the Authors to properly include CCFs in the Transition Diagram and Matrix; it has to be pointed out that CCFs:

◊ Add new Transitions;
◊ Do not add new Cumulative Residence States;

Therefore, it is possible to “superpose” the CCFs and their transitions to the previous transition diagram without CCFs. The new CCFs and their transitions have to be “ordered” in such a way that they will be with higher sequential codes; in this way they will appear only in a peripheral strip of the transition matrix. In Fig. 3 it is possible to see that the internal (grey) part of the transition matrix is “without” CCFs, and the external (light) strips are relevant to CCFs.

8. TOPIC – AUTODIAGNOSTIC

A reliability / cost optimization must take into account both the impact of the “heavy” faults and the long outages (loss of energy delivery) due to their long repair times.
Auodiagnostic proved a very effective technique to reduce dramatically the probability of “heavy” faults on main equipment; in fact, the degradation factors are permanently monitored, and it is possible to detect and to decide when and how to repair the fault before it becomes the cause of a serious equipment damage.

A specific study [9] has been carried out comparing the outage time of two EHV (Extra High Voltage) Substation alternative configurations:

1. 1½ Circuit Breaker Scheme – Tot. 9 High Voltage Circuit Breakers
2. Single Circuit Breaker Scheme – Tot. 6 High Voltage Circuit Breakers

The comparison showed that with the adoption of autodiagnostic it is possible to adopt the simpler (cheaper) 2) configuration with almost the same reliability. In fact, the adoption of autodiagnostic has a relevant impact on the simpler configuration, and conversely a negligible impact on the more expensive one, that is already very reliable.

It is possible to evaluate the impact of autodiagnostic, with the following sequence, in the frame of the above described methodology.

The faults which can be detected in their early stage by autodiagnostic should be identified and separated since the beginning in the FMEA (Failure Modes and Effects Analysis).

Two separated sets of faults should then be considered in the transition diagram, which will have the same residence states. The problem is that if the new “heavy” faults would be included (added) in the original frame, it is very likely that the transition matrix could became too large to be easily handled; this is the biggest limit of the Markov Process. The solution is to carry out two separate Markov analysis, considering the same transition and matrix diagram as follows (symbols and codes are same as for (1)):

A. A Markov analysis with all the faults but the “heavy” ones; it has to be pointed out that in this case it is necessary to evaluate the power NOT delivered in every residence state, instead of the delivered power.

\[ \text{UP}_A = \sum_{i=1}^{n} (1 - Ap_i P_i) \]  \hspace{1cm} (2)

B. A further Markov analysis with the same residence states, but considering only the “Heavy” faults.

\[ \text{UP}_B = \sum_{i=1}^{n} (1 - Bp_i P_i) \]  \hspace{1cm} (3)

The Average Power Delivery, not taking into account the simultaneous probability of outages (REA – Rare Events Approximation), is
The power loss efficiency (PE) can be calculated using the equation:

\[
PE = \frac{[1 - (P_A + P_B)] + 100}{PT}
\]

\[\text{(4)}\]

Fig. 4 – EHV SubStations Schemes
9. TOPIC – LONG REPAIR TIMES

Long repair times of the main equipment have of course to be avoided as far as possible, because they correspond to long power outages. A recurrent situation is that, simply in order to maintain a standard design, a more expensive High-Tech solution is adopted in cases where a non High-Tech solution could be proposed, with approximately the same cost (sometimes cheaper); the problem is that a High-Tech solution usually has a long repair time and requires very skilled (expensive) repair team, conversely a standard solution is easily restored in service.

A typical case is the High-Voltage interconnection between the Main Step-Up Transformers of a Power Station and the High Voltage Grid. Along many decades this interconnection has been provided by means of a short aerial line, but in the last decades many interconnections have been done with High Voltage cables buried in the soil; this latter solution was originated in order to avoid exposed aerial cables in urban areas.

The HV cables then became almost a standard solution, and now it is common to find them also in Power Stations installed in not industrialized areas. It has to be pointed out that a cable has a lower unit (1/km) failure rate than an aerial line, which is subject to lightning strokes etc., but in the case of a cable there is to add the failure rate of the cable terminations at the two extremities, which is not low and fixed i.e. independent from the conductor length; eventually, the overall failure rate a short HV cable is of the same order of that of a short aerial line; unfortunately, the repair of a HV termination is quite expensive (it requires High Tech components and very skilled personnel) and the repair time is much longer than for an aerial line. An interesting study covering the HV cables repair times is reported in [18].

Of course, the long repair times play a more important role in non industrialized countries, and mainly in case that the power station is predominant; conversely their role can be relevant but not dramatic in countries with very developed and interconnected HV grid, where the same grid is providing a sort of network redundancy.

Also the interconnections of the Wind generators, and the main HV interconnection between the Wind generating park and the HV grid are usually provided with buried cables [19], with sometimes heavy problems; an alternative with Medium Voltage aerial lines for the generators, and HV aerial line for the main interconnection, should always be taken into account.

In order to limit the size of the transition diagram and matrix, the above mentioned interconnections can be included in “macrostructures” as an extension of the equipment they are connected to; the theory of the “macrostructures” is comprehensively treated in [3].

10. REFERENCES


Webproject - Customization Project Management Software

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¹ Began his career as a trainee in the design department of a medium-sized construction company between 1999 and 2002, then migrated to a developer of residential projects (in the area of inspection works). Graduated in Civil Engineering in 2005 at IMT (Mauá Institute of Technology), when he returned to the project area (structural) opening his first company. From 2007 to 2015 he participated as a partner in a design firm, specializing in large logistics and industrial developments. He is currently the technical director and responsible for the development area of the WebProject platform.

² He began his career in Construction and Technical Building in 1993, working as a budget officer for a small construction company. As an architecture intern he worked in architecture and design development offices, town planning and monitoring of works, and graduated in 2001 at the Belas Artes SP, and continued acting in monitoring implementation works of corporate offices. In 2004 he was hired as a Project Coordinator in Rational Engineering, where he had the opportunity to work in various areas, such as logistics, industry, shopping malls, Critical Mission Buildings, actively participating in the formatting and evolving standards Project Development for both ISO 9001 and for internal procedures. He specialized in Project Management in 2009 by the Getúlio Vargas Foundation and resigned from the company in 2011, in search of his ultimate goal of building a strategic management office for construction. In 2015, he met WebProject, and is now responsible for the training and application of the platform to the reality of companies.

ABSTRACT

The present work has the scope of presenting a new online tool of Project Management, the WebProject, aimed mainly at the Civil Construction Market, with the purpose of integrating all the processes of Project Management.

As a startpoint for the development of the website, PMBOK parametres were used, as well as the professional experience of the developers in Civil Construction's Project Management.

The sustainability parametre, which is imperative for the new challenges involving engineering and design is also contemplated.

We have made a profound study of the tools available in the market, both as users and administrators, and we have found out that the leading platforms also work for the interrelation between processes. We concluded that this is a poignant necessity of the market which lies in the collective unconsciousness of a great deal of project teams in big organizations.

However, the challenges faced in the integration of processes often come up against the company's culture, as well as user's high specialization of non-integrating tools and the lack of training for the relevant aspects of Project Management, which undermines the success of softwares that were developed for this purpose.
As we understand that Process Integration reduces drastically the risks caused by lost information, allowing the validation of the most effective steps of the project, and thus bringing a great deal of transparency between agents involved in the process, we are making efforts alongside the Project Managers of partner companies, so we can take our product to the reality of these companies.

Integration brings direct cost benefits, improves deadline control and increases the performance of the Project Manager, for it avoids the waste of resources in activities susceptible of automatization, and allows them to dedicate to relevant strategic activities.

II. INTRODUCTION

One of the great challenges faced by companies in the hiring of a Project management website is that somehow users have to abdicate of working patterns accumulated during the company's history so they can accommodate themselves to a pre-established rigid format.

Because of that, the website's utilization ends up restrict to some facilitating tools and resource integration is never concluded.

Part of the difficulty resides in the high specialization that some softwares demand of their users, and which almost always produce quite effective results.

Two questions arise from this situation: does the Project Manager effectively use all of the possible operations in the application? Were a simpler tool, integrated with other parts and agents of Project Management, to be made available for the desired purpose, wouldn't it add more to the work than the profundity of the use of the tool in which the Project manager specialised?

There's yet another great difficulty in relation to the company's database. Whether it concerns formalities, archives or scope control, for each of the nine fields in PMBok, modern companies have diverse documents and information in their database that cannot be overlooked in the website's integration works.

III. HISTORIC

The concept of standardization is as old as the history of human writing, which translates the language spoken by an individual into the shape of codes shared by a group, family, city or civilization.

The whole crafted process of human history always based itself mainly in the functional aspects of the object, function as a consequence of necessity, an aggregate of cultural and aesthetical aspects. This sum of ingredients has always defines the standards of products generated by each individual.

With industrialization in the 18th century, there's the reinforcement of the concept of standardization, and a new component of great relevance to manufacturing production arises – quality control.

The creation of rules of production and quality aimed at the improvement of resources and client satisfaction was necessary, so that quality control would have the effect desired by productors.
German psychologist Carl Gustav Jung was one of the main thinkers of modern age to research the fact that scientific reason of individuals follows patterns and tendencies. Through his theories of collective unconsciousness archetypes, he demonstrated that often what we believe to be involuntary creations of our minds are actually ‘tendencies’ given by our ancestors, which permeate our time with more or less intensity according to the group in which one is inserted.

This reference is very relevant in this article which seeks to deal with conflicts between individual x the company's culture; company culture x market standards; and especially the attempt to customize the Project management’s website to the company’s culture.

Since ancient times man manages its activities, but from the early twentieth century we began to theorize about this action, seeking to mitigate risk, maximize results and propose continuous improvements.

In the early twentieth century, it is FREDERICK W. TAYLOR, American engineer, who presented the principles of scientific management and the study of MANAGEMENT as a SCIENCE.

Known as the precursor to the theory of scientific management, Taylor advocated the practice of the division of labor, emphasizing times and methods to ensure its objectives, the maximum production with minimum cost following the principles of scientific worker selection, the standard time, collective work, supervision and emphasis on efficiency. Also human relations, in which the welfare of workers was one of the factors for the proper functioning of the organization and the achievement of the goals set for it.

He applied scientific reasoning to show that work can be analyzed and improved by focusing on its elementary parts, and developed his theory in the activities found in the steel industry.

In the considerations of the SCIENTIFIC ADMINISTRATION by Taylor, the organization is compared to a machine that follows a pre-defined project; the salary is important, but not critical to employee satisfaction; the organization is seen in closed form, independent of its market; employee qualification becomes redundant as a result of the division of tasks that are performed monotonously and repetitively and, finally, the scientific management makes use of employee exploitation on behalf of private business interests.

In Europe other theorists were formulating critical theories of management at the beginning of the last century, as is the case of Henry Faiol with more humanistic features, where human relations, compensation and prevalence of general interests were incorporated into the hitherto modern concepts of american administrative practices.

Since then, several theorists, such as Elton Mayo Gerge, John Dewey and Kurt Levin, identified the human factor as central to the development of organizations.

This creates a major change in the structures of companies, which in the late 50's, no longer related to the machines and started to seek organizational structures.

Before Taylor, the only way to improve productivity was to demand workers more hours of hard work.
Taylor plays an important role in project management history, but it was his partner, Henry Gantt (1861-1919) who studied in detail the order of operations in work.

His project management studies have been used to build ships during World War II. Gantt built diagrams with taskbars and milestones that sketched the sequence and duration of all tasks in a process.

Gantt diagrams proved to be an analytical tool so powerful for managers that have remained unchanged for nearly a hundred years. No change in the Gantt chart was introduced until the 90s, when there were added connection lines to the task bar describing more precise dependencies between tasks.

Taylor and Gantt and other scholars helped develop the process of management as a distinct business function that requires study and discipline.

At this time, the need to organize and guide the way to manage these organizations appears. The projects, mostly sponsored by the state, stimulated growth in the management area and were decisive for the creation of groups trying to standardize its implementation.

In the United States, the first major organization to put such concepts in pratic was the Central Pacific Railroad 3, which began its activities around 1870, with the construction of the transcontinental railroad. Suddenly, business leaders faced themselves with the complex task of organizing the activities of thousands of workers, manufacturing and assembly of unforeseen amounts of raw material.

In the decades following World War II, marketing strategies, industrial psychology and human relations began to integrate business management and the administration of companies.

The complexity of projects demanded new organizational structures and unforeseen Network Diagrams called PERT charts (Program Evaluation and Review Technique) and the Critical Path Method (Critical Path Method - CPM) was introduced, offering professionals greater control over projects.

During World War II, the growing need for weapons and ammunition forced the industry to create several points of production in different geographical locations, resulting in the creation of norms and tolerances so that the various pieces would fit together with each other.

In a way, this circumstance gave motivation to the creation of the first global partnership in 1947, International Standardization Organization - ISO (World Organization for Standardization). This entity was formed by standardization bodies in each country. Its main objective is to seek standardization worldwide in order to facilitate trade between countries.

Technical standardization has as main objectives:

- To protect the population on issues related to health and safety;

- To define the requirements for achieving the quality requested by the client;
• To provide solution to repetitive problems by increasing productivity and reducing waste, thus contributing to the conservation of natural resources and the environment;

• To ensure the absorption and transfer of technology;

• To facilitate international trade.

IV. SIMPLIFIED ANALYSIS OF AVAILABLE TOOLS

1. Consecrated Tools

1.1. Microsoft platform

In the 70s, the association of two young students, Bill Gates and Paul Allen, was responsible for one of the biggest revolutions in contemporary history, which was the creation of the Microsoft platform (which made possible the popularization of PCs).

Since then, increasingly larger teams and more specialized programmers have developed work tools that have become virtually indispensable in the life of companies.

The Windows operating system is used in most Brazilian companies. According to the agency that regulates the use of open-source operating systems in Brazil, the Windows platform dominates 77% of the market.

With the development of Windows, a package of work organization applications was created. It virtually removed all local competitors that were used by private users and companies. The Office Package:

Word can synthesize all the possibilities for creating documents and reports, with great customization capabilities.

Excel is actually a working basis, since it can, through mathematical settings of infinite complexity, perform almost all financial operations of reporting and control that companies need in their daily lives.

Power Point is a simplified tool widely used for the presentation of work between teams and also to the customer.

Access is a database tool, the application of which is quite limited in Brazil.

1.2. The Microsoft Office Project is an application widely used in project management, with a number of specific tools that allow for simplified control of the project without activities and links, to the measurement of efficiency during the time intervals, periodic disbursements and definition of critical paths.
It is basically made up of a database of same scope activities, which is based on a model of activities precedence network.

Project, with all its current resources, allows online real time management of the activities involved in the Project. It also allows that the users keeps track of their project plans (regardless of size), develop sophisticated reports compatible with other Office applications helping to measure progress and allocate resources, making it also possible that, with the Task Path highlighted in the Gantt chart, the users know hows their tasks are linked and identify what are the most important to the success of the project; creates quite manageable schedules also with links to project costs.

With MS Project it is possible to exchange data with both ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) systems, other than being very integrated with the so-called views of other Office applications. You can also add auxiliary tools for developing WBS structures and Pert Chart and creating internal applications to the system using the VBA language and other programming interfaces provided by Microsoft.

1.3. Primavera platform;

The American company Oracle, created almost thirty years ago by Larry Ellison, saw that virtually no company had an efficient operating system to the control of Operation and Relational Database. The fact that Oracle has always been dedicated only to the development of business solutions, made it achieve resources rapidly for major innovations. As much of the market does, today Oracle develops solutions to collective work.

The flagship of the Project Management market, widely used in Brazil, and mainly in IT, is the Primavera.

The Primavera has the great advantage of allowing platform configuration according to the employee’s role within the company, from the Manager to the Operational.

For the Project Manager, it promises various types of reports that allow a very detailed view of the Project deadline, the cost and also the scope.

The Primavera has the so-called High End Project Planner, which are large-scale settings geared for each type of industry:

- Engineering and construction;
- Professional Services and Consulting;
- Energy and Process;
- Telecommunications;
- Public sector;
- Aerospace and Defense;
- Financial services.

With the Primavera it is possible to set up your own desktop and interact with the client, setting up a
flow of approval.

2. Risk analysis tools

Risk analysis tools are scarcely used by Engineering and Construction companies in Brazil because of the difficulty in cataloging results and statistics with such diverse scope.

The general profile of most Construction companies in Brazil at the same time enable the same construction company to meet different market segments with different constructive solutions, thus making it difficult to model a repetition plan identifying risks by statistics.

Today risk management is done through forms like “Lessons Learned”, and through the transmission of experience among peers.

Risk tools used in the world are:

- Crystal Ball;
- @RISK
- Welcom Risk;
- Precision Tree

3. Tools for special purposes;

3.1. HR Tools

- Mind Manager

A tool that sets up a network of Environmental Factors of the Company, with cost settings by professional, availability for work, interest, qualification and experience in the type of work to be selected.

- Minute Man – Hour Control and Appropriation;
- Navis – Activity Control of Architecture and Engineering offices.

3.2. Software Documentation:

- Meridian;
- Doc-to-Help.

3.3. Textual Research Tools

- Dt Search Support

Does full text search in different document formats; It has a viewer to different formats.
3.4. Software of field activities control

- Punchlist;
- Vantis;
- Produttivo.

4. Collaboration Tools

Collaborative systems have, by definition, the use of software features and connectivity between computers to perform group work.

They allow groups scattered in different regions and times to perform group work.

Collaborative systems work as:

- Central document repository;
- Flow of approval of documents and decisions;
- Automated control of events;
- Pendencies control;
- Asynchronous communication between working groups;
- Discussion and exchange of ideas;
- Online vote;
- Chat and video conferencing;
- Brainstorms

In theory, the greater the number of connections, the more enhanced the result of the work will be. The quantity of communication channels can be done by the following formula:

\[
N^2 \frac{(N-1)}{2} = \frac{N^2 - N}{2}
\]

N = being the number of participants.

Some collaboration tools available in the national and international market:

- SADP;
- Autodoc;
- Lotus Notes;
- Trello;
- On Project;
- Planview
- Confluence;
• Construtivo;
• Genius Inside;
• Groove;
• Hypper Office;
• ProjecBuilder;
• ProjectPlace;
• Construmanager;
• Webex;
• Viecon;
• TeamDesk;
• ProjectWise;
• SharePoint.
• Google - docs, forms, schedule.

V. WebProject - DESCRIPTION AND FUNCTIONALITY

1. History

In early 2012 began the construction of the WebProject platform.

The whole system was designed based on OpenSource technologies from the operating system to the elements that make up the user interface, and it is based on:

• Cloud Computing: distributed system of servers that allows to deliver customers a highly stable system and high levels of availability and redundancy for both the units of processing (cloud computing), storage (storage) and database. All development provides full flexibility in relation to the computing infrastructure provider, allowing imperceptible migration for the user to meet service level changes, contractual demands and cost optimization. Currently, we are operating on the AWS infrastructure (Amazon Web Services), the world leader in the segment that has several international certifications and safety compliance (https://aws.amazon.com/compliance/ and https://aws.amazon.com / security /), and the confidence of large corporations and organizations (such as NASA, Dow Jones, General Electric, Siemens, Unilever, etc.) and technology companies and highly innovative and disruptive startups (like Netflix, Airbnb, Spotify, etc).

• Linux operating system: We have adopted various distributions for each application that comprise our platform. On our servers, we have OpenSource software for delivery of essential services as WEB server (HTTP / HTTPS), E-mail server (SMTP), Calendar Server (VAD) among others, and also reliable solutions to meet the internal demands of the platform.

• Versioning of the code and tests: To control our development, we adopted the versioning system GIT, which allows you to answer promptly to timely updates on the platform, keeping a complete history of changes and also who was responsible for them. Thus, we currently apply various daily changes with new features and performance improvements without service interruption, in a transparent way to the final user.
The adoption of these strong assumptions since the creation of the system’s first functionality, linked to a clear definition of the objectives to be achieved, shared by the entire team, and the use of agile development methodologies, allowed us continuous and sustainable evolutionary growth with very high level of customer satisfaction, and giving us total freedom to always follow the latest trends technologies.

In the coming months, we will launch what is internally called version 2.0.

It will be a great change in visual communication platform with innovative UX features (User Experience) and simultaneously the launch of native mobile apps (iOS, Android and Windows Phone).

2. Need / Opportunities

The technical background of the partners provided the contact, as users, with the various tools available in the market.

The solutions were often inflexible, leading the contractor to suit the rigidity of processes designed by the supplier. Even the most flexible tools lacked integration, addressing only the solution to a specific problem (whether of communication, traceability or control), but still leaving loose edges in the overall flow of the project.

So we started with a product that would meet the market more broadly, but also serve as a basis for the other demands that would arise with the platform expansion: a file sharing system.

In this product, we include the features that a project manager expects (standardization of file-name, revision control, automatic notifications, workflows, per-user access permissions / team and status, etc.). All in an extremely customizable way, effectively leaving the entire project control in the hands of the manager.

From these initial features, we went to more advanced levels of automation. For example: the creation of an application to be installed on the user’s workstation (Windows), which through an API (Application Programming Interface) allows the issuance of files to the platform without the need for the user to access the system via Browser web. And we went further. Through an application designed to run within AutoCAD, users could make emissions of drawings with a few clicks, with some tasks being done automatically: obtaining the description of the design, generating the DWG, PDF, PLT and DWF formats and Internet sending to second plan and enrollment in the destination folder.

3. Barriers to full management

The very definition of “what is a Project” brings us clues about the management challenges associated with the process. According to PMI, a project is:

“... A set of temporary activities carried out in a group, designed to produce a product, service or unique result.”
The unique nature of a project brings unpredictability and risks of various kinds, and this directly reflects the difficulty of having a single tool to do its management.

Still in regard to the Brazilian construction market, other points should be considered:

- Diversity of enterprise typology;
- Diversity of corporate cultures and company size;
- Adherence to methodologies, know-how and processes of businesses;
- Levels of education and training of both managers and the extremely heterogeneous operating staff;
- Diverse capability of investments;
- Lack of integration between multiple tools adopted by the company (or by professionals).

4. Approach

The way that was found to cover the market needs as widely as possible was the development of a modularized and integrated, but above all customizable platform. Providing the essential tools for development and project management, but also allowing the user to customize the platform according to his needs and, when deemed productive, use other tools for specific activities (exporting the platform information in formats compatible for external treatment).

5. Where we are

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<tr>
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<th>Conceptualization</th>
<th>Development</th>
<th>Validation</th>
<th>Operation&amp; Evolution</th>
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<td>Risk Forecasting Module;</td>
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6. Where we want to get

The ultimate goal of WebProject is becoming a project management tool capable of integrating all stages of the design process, implementation and operation of the project.
We are focused on the civil construction market and its variations, and understand how the automation of some processes can represent great capability of savings for the enterprise and the entrepreneur.

We base our standards on principles defended by PMI, but we understand that the higher the customization to the mode of production and standards that each company or user is used, the greater our success in product acceptance.

6.1. Scope Management

Describes the processes involved to verify that the project includes all the work required - and only the necessary work - so it is successfully completed.

PMBOK Definition

Based on this definition we aim to:

6.1.1. Create a database for product design, which can store information of the type:
- Marketing analysis;
- Market research;
- Trend analysis;
- Analysis of the surrounding features - available infrastructure;
- Morphological Analysis of the land - elevation map and slope map;
- Identification of complications on the ground;
- Municipal Guidelines;
- State Guidelines;
- Federal Guidelines;
- Guidelines of Public Services Concessionaries;
- Guidelines of Insurance Companies and National and International Regulatory Agencies;
- Gated Community Guidelines and Neighborhood Associations;
- Regulatory restrictions imposed;
- Customer needs Questionnaire;
- Operating Plan;
- Master Plan;
- Illustrative images;

6.1.2. Create a database for each standard scope company to be selected for the contracting of partners that can be controlled through the project cycle;
6.1.3. Generate the WBS project;
6.1.4. Highlight the activities required for the completion of projects;
6.1.5. Track changes of the projects through Modification Orders forms - Change Orders - filtered through our Occurrences programming base;
6.1.6. Generate and control database of inputs and services.
6.1.7. Store the contract files;
6.1.8. Store the Project Opening Term.

6.2. Time management

Describes the processes related to project completion at the right time.

PMBOK definition

6.2.1. To develop activities schedules with preceeding interconnected with the Agenda Module and Scope Module;
6.2.2. Schedule Control through Baseline and production “signalizers”;
6.2.3. Identify in the own schedule the events that caused damage or benefits to the initial planning time;
6.2.4. Having a shareable calendar module with other platforms that serves as “signalizer” of daily activities, in which the intervention of the Project Manager is required so that the schedule is not delayed;

6.3. Cost Management

It describes the processes involved in planning, estimating, budgeting and cost control to ensure that the project is completed within the approved budget.

PMBOK Definition

6.3.1. Insert in the scope of the database the costs of each input and service;
6.3.2. project cost control as a whole, aiming especially the requested changes of scope, allowing the validation of the same through the link with the financial impact;
6.3.3. Control of contracts with service providers of the project field and consulting services through measurement forms;
6.3.4. Packing lists for totalization of NF by inputs and services;
6.3.5. Proposals involved in the process - checked and approved;
6.3.6. Preparation of Physical and Financial Timetable of the main activities of the enterprise;
6.3.7. Preparation of Physical and Financial Timetable of Engineering Projects;
6.3.8. Calculation of global investments for business viability;
6.3.9. Calculation of the project’s return rate.

6.4. Quality management

It describes the processes used to ensure that the project will satisfy the objectives for which it was designed.

PMBOK Definition

6.4.1. Create customized forms for Service verification;
6.4.2. Create customized forms for project analysis;
6.4.3. Improve our module of quality inspection;
6.4.4. Improve our reports of non-compliance;
6.4.5. Create evaluation forms of services and service providers;
6.4.6. Database of rules to which the project is submitted.

6.5. People management

Describes the processes that organize and manage the project team, processes for the collection, dissemination, storage and final disposal of project information in a timely and appropriate manner.

PMBOK Definition

6.5.1. Supplier Registration Form;
6.5.2. Suppliers Database;
6.5.3. System of continuous evaluation of suppliers;
6.5.4. Selection of service providers;
6.5.5. Definition of the hiring scope for services;
6.5.6. Standard contract;
6.5.7. Contract of Service Delivery with each supplier;
6.5.8. Database of technical responsibility notes of each supplier;
6.5.9. Set the “tree” of the project and its interconnections;
6.5.10. Establish a workflow for the project;
6.5.11. Setting rules for the internal communication of the project;
6.5.12. Definitions of standards and nomenclatures of file representation and documents facilitating the integration of information;
6.5.13. Record of relevant information;
6.5.14. Registration of document shipments;
6.5.15. Regular meetings;
6.5.16. Meeting of scope transfer to other staff;
6.5.17. Set criteria for an objective evaluation, whenever possible, keeping the database up to date;
6.5.18. Provide feedback to the team involved in the project;
6.5.19. Connecting with hour appropriation systems for verification of project performance.

6.6. Risk management

It describes the processes concerning the implementation of risk management in a project.

PMBOK Definition

6.6.1. Risks to the neighborhood - EIV;
6.6.2. Risks to the Environment - environmental studies;
6.6.3. External risks that may impact the success of the enterprise;
6.6.4. History of similar situations;
6.6.5. Analysis of all legal documentation of land - inheritance, dispositions, processes, unconsolidated
currencies, occupations, etc;
6.6.6. Environmental liabilities analysis and of the lot patrimony and its environment
6.6.7. Lot probe analysis report
6.6.8. Analysis of the lot and its surrounding features for the type of proposed development;
6.6.9. Historic analysis of approval steps for similar projects;
6.6.10. Specialized study in all spheres of approval that allows to verify the need for hiring expert advice;
6.6.11. Verification of the structural system from the foundation to the roof;
6.6.12. Availability check of materials and equipment specified for the project and its surroundings;
6.6.13. Check of all premises plants set by the designers;
6.6.14. Check of the aspects of thermal and environmental comfort;
6.6.15. Verification of durability and maintenance of the building criteria;
6.6.16. Generation of a Database of 'Lessons Learned' by the company.

6.7. Acquisition Management

It describes the processes of product purchase and acquisition, services, or results outside of the organization that implements the project.

PMBOK Definition

6.7.1. Select the scope to be hired;
6.7.2. Establish premises, rules and procedures required to service performance;
6.7.3. Select and qualify the suppliers for the best achievement of the scope and intended results;
6.7.4. “Shoot the quotations” for the selected suppliers;
6.7.5. Elaborate Maps of Proposal Equalization;
6.7.6. Set the vendor and monitor its performance;
6.7.7. Final evaluation and delivery of the scope.

6.8. Integration Management

It describes the processes and activities that integrate the various project management elements which, in turn, are identified, defined, combined, unified and coordinated within the groups of project management processes.

PMBOK Definition

6.8.1. Development of the Project Plan;
6.8.2. Consolidation of scope information through Meeting Drafts;
6.8.3. Details of job tasks and their responsibilities through Meeting Drafts;
6.8.4. Control of project plan - through Continuous Form of currencies;
6.8.5. Validation of the project plan - through Meeting Drafts;
6.8.6. Defining organizational policies applied to the project – definition of communication standards, presentation and behaviour in the team - the Annex;
6.8.7. Control of Preventive measures – through Pendencies list;
6.8.8. Control of Corrective measures - through Project Analysis Report;
6.8.9. File and document control
6.8.10. Changes in the project plan - through Continuous Occurrences Form;
6.8.11. Registration and Validation of Change Requests in the project plan - through Meeting Drafts;
6.8.13. Documents proving of scope changes - attachments;
6.8.14. Record of closure of all stages of the process - through Meeting Drafts;
6.8.15. Check List to verify the compliance of the scope originally proposed;
6.8.16. Sheet of assessment of deviations occurred;
6.8.18. Formal presentation to project closure.

6.9. Sustainability Management

Describes the processes to encourage strategies to minimize the impact on the ecosystem during the implementation of the building and addresses fundamental issues of major urban centers, such as reducing car use and heat islands.

Definition by Green Building Council Brazil

6.9.1. Hiring definition of certifying agency in the project to be adopted;
6.9.2. Sustainability Check List;
6.9.3. Details of job tasks and their responsibilities through Meeting Records - WP;
6.9.4. Control of the sustainability plan - through Continuous Occurrences Form;
6.9.5. Forms and certification agency specific system.
6.9.6. Validation of the sustainability plan - through Meeting Records;
6.9.7. Control of Preventive measures – Through Pendencies list;
6.9.8. Control of Corrective measures - Through Project Analysis Report;

VI. CONCLUSION

When exposed in the summary that the purpose of this work is the presentation of the online tool for project management, in fact the above mentioned is that the need for integration has been increasing in the last years, precisely because of the great globalization of normative standards that impact directly on the daily lives of civil construction companies in Brazil. Today, for instance, several parameters that determine the approval of a project in the Fire Department of the Brazilian States, are based on NFPA (National Fire Protection Association). ISO certifications and environmental requirements are mandatory for companies that need to execute projects for multinationals, within and outside the country.

PMI itself has very targeted lines for the development of the Project Manager’s work, which is very valid because each standard or rule is a result of the experience of application of new technologies, and of ethical rules that serve as a great tool for Risk Management in a business.

What this work intended to demonstrate, in fact, is that all standards that are too rigid imply the suppression of values and culture of the individual and the company, and it is for this reason that the online application Project Management cannot complete the integration of all processes. One cannot rule out
the greatest asset of companies, which is their organizational culture, gained through the experience of each team member.

We know that this is hard work, because often users must give up their specialization in traditional applications and devote energy to integration, but we know that the result of a well integrated process produces visible results for the organization and for the environment in which it is inserted, for it is sustainable, avoids waste of resources, and especially, it allows to focus on what is really important.

Often, while working with project management, we see ourselves “looking at ants while the elephant goes on our backs”, and to avoid this we see as fundamental to the success of an online Project Management tool.

We could then group the types of bonds and restrictions associated with the management of the projects as follows:

<table>
<thead>
<tr>
<th>Restrictive or regulatory</th>
<th>Directive or guiding</th>
<th>Flexible or variable</th>
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<tbody>
<tr>
<td>- Rules</td>
<td>- Management methodologies</td>
<td>- Tools</td>
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<tr>
<td>- Legislation</td>
<td>- Good practices</td>
<td>- Corporate culture</td>
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<tr>
<td>- Companies’ values</td>
<td>- Procedures</td>
<td>- Human capital</td>
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<tr>
<td>- Ethical values</td>
<td>- other</td>
<td>- other</td>
</tr>
<tr>
<td>- Other</td>
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</table>

Each item can have more or less value to a particular organization or even vary between projects of the same company, which leads us to the conclusion that despite the existence and need to comply with certain standards, the imposition of a rigid tool or of one that does not adhere to key areas of the company and its users invariably leads to loss of efficiency in project management.

We understand, as efficient management of the project, the possibility of a clear view of all aspects related to its development (scope, cost, time, etc.) but above all the possibility of making the integration of these fronts in an agile, transparent, shared and traceable way. This allocation of responsibilities and delegation of functions is essential for the project manager to focus in the maximum of its core business and to manage better and more.

For the implementation of a solution of this size to succeed it must be seen as a cyclical and evolutionary process, in which the difficulties of a specific project are reversed in differentials in the next, allowing all to share this learning at the institutional level, fostering innovation and oxygenating the culture of the company:

- To know the companies’ norm base and standards;
- To receive training on the knowledge that the organization applies in its projects;
- To apply knowledge in WebProject programming bases;
- To share the application modeled within the system;
- To track operational flow of users;
- To validate the Management System deployed;

To continuously improve the system combining market innovations and internal changes to the Company.
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VIII. WEBPROJECT TEAM

Felipe Oliveira Mesquita: began his career as a trainee in the design department of a medium-sized construction company between 1999 and 2002, then migrated to a developer of residential projects (in the area of inspection works). Graduated in Civil Engineering in 2005 at IMT (Mauá Institute of Technology), when he returned to the project area (structural) opening his first company. From 2007 to 2015 he participated as a partner in a design firm, specializing in large logistics and industrial developments. He is currently the technical director and responsible for the development area of the WebProject platform.
Marcos Fernando Haffner: He began his career in Construction and Technical Building in 1993, working as a budget officer for a small construction company. As an architecture intern he worked in architecture and design development offices, town planning and monitoring of works, and graduated in 2001 at the Belas Artes SP, and continued acting in monitoring implementation works of corporate offices. In 2004 he was hired as a Project Coordinator in Rational Engineering, where he had the opportunity to work in various areas, such as logistics, industry, shopping malls, Critical Mission Buildings, actively participating in the formatting and evolving standards Project Development for both ISO 9001 and for internal procedures. He specialized in Project Management in 2009 by the Getúlio Vargas Foundation and resigned from the company in 2011, in search of his ultimate goal of building a strategic management office for construction. In 2015, he met WebProject, and is now responsible for the training and application of the platform to the reality of companies.
Economics of Green Building – South African stakeholder perspectives

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ABSTRACT

Purpose of this paper (mandatory)

This paper examines if South African green building can enhance the asset value of the building. It is often perceived that the benefits of green buildings accrue to tenants or longer term owners but not necessarily for developers.

Design/methodology/approach (mandatory)

A questionnaire based on a 5-point Lickert scale obtained data from respondents to describe the market perceptions on the study subject. The questionnaire profiled the respondents and evaluated opinions on the cost and the additional economic value added by green building. The questionnaire was forwarded to 80 practising developers, architects, quantity surveyors and project managers from the Gauteng Province, South Africa of which 64 responded.

Findings and value (mandatory)

The study confirmed that 92% of stakeholders expect green developments to attract a capital premium due to material, design and submission cost. Only 38% agree that developers currently benefit from green building. However 70% agree that after 5 years economic benefits will be realised and 75% believe that green buildings will retain a higher market value.

Research limitations/implications (if applicable)

The study was limited to Gauteng Province only and did not include stakeholders such as green building consultants, consulting engineers or academics. The study was also limited to the opinions of respondents and not on factual data from actual developments. All of the above mentioned aspects should be explored and addressed by future research studies.
Practical implications (if applicable)

The lack of conclusive proof of the benefits of green building is a challenge that may hamper growth of green development. About 40% of respondents are not knowledgeable or involved with green building. Continued education and communication efforts are needed to increase the number of active green building participants.

Originality/value of paper (mandatory)

The study revealed specific opinions of practising stakeholders on important economic aspects of South African green building practises. The emerging South African green building industry needs information to inform stakeholders and guide future decisions. Various other research topics for future research were identified.

Keywords (no more than 5): Cost premium, Economic benefits, Green Building, South Africa, Stakeholders

1 INTRODUCTION

The construction industry consumes 40% of the world’s energy and 25% of its fresh water. The World Green Building Council (WGBC) confirmed that 30% of global greenhouse gas emissions originate from the built environment (2010). Various others studies (Haapio & Viitaniemi, 2008; Toller et al, 2011: 394) also highlighted that many of the world’s environmental pollution and resource depletion are caused by the building and property sector. In 2009 the Construction Development Industry Board (CIDB) confirmed that similar statistics also apply in South Africa (CIDB, 2009). Milne confirmed this opinion and reflected that South African buildings generate a third of all local global carbon emissions and produce 40% of waste going to landfills (Milne, 2012: 16).

The construction industry had to address the negative environmental impact associated with buildings. The world slowly started to transition towards more sustainable consumption and product patterns. Real estate developments had to become more environmentally sustainable. The concept of Green buildings was born from the demand for greater resource and energy efficiency from buildings. However the WGBC reflects that green buildings deliver much more and needs to be viewed much more holistically (WGBC, 2013: 15).

2. GREEN BUILDING COUNCILS

The World Green Building Council was established in 1998 with nine founding members and 66 other countries have subsequently joined the WGBC (WGBC, 2016). The different countries developed green building rating tools to evaluate and certify green buildings to suit their local conditions. Three of the best known green building rating systems are the Building Research Establishment Environmental Assessment Method tool (BREEAM) launched in the United Kingdom (1990), Leadership in Energy and Environmental Design (LEED) launched in the United States (2000) and the Green Star system launched in Australia (2003) (WGBC, 2014).
The Green Building Council of South Africa (GBCSA) was established in 2008 (GBCSA, 2015). The South African Green Building industry has made positive progress since then, specifically with the construction of new green office buildings. During the period 2009 – 2015 the GBCSA certified a total of 197 buildings with a 4 Star or higher grading with 158 of those being new office buildings. The retail, industrial, residential and public sectors of the South African industry as well as the conversion of existing buildings are still lagging behind. These segments of the industry are still in the early stages of accepting and utilising Green Building principles.(GBCSA, 2016).

3. BENEFITS AND BARRIERS OF GREEN BUILDINGS

Since the inception of the green building industry the property industry experienced challenges that hampered the growth of the industry. More than a decade ago Kats (2003a) stated that the perceived cost premium associated with green building was a significant entry barrier for new green developments. In South Africa Milne (2012: 16) also confirmed the perception of upfront cost as the biggest barrier. Other South African green building challenges are shortage of industry skills, the cost and availability of green products and material, the cheap local prices of energy and water, the lack of incentives for demonstrating best green practice, inadequate or conflicting government regulations and the difficulty with valuing green elements.

3.1 Cost premiums and International markets

In an effort to clarify the perceived cost premium Kats in a follow-up study contacting several dozen building representatives and architects in order to secure the cost of 33 green buildings from across the United States (US) (2003b, 2). He found an average green cost premium of less than 2%, substantially lower than was commonly perceived. The majority of the cost was due to increase architectural and engineering design time, modelling cost and the time necessary to integrate sustainable building practice into projects. Kats also found that the sooner the green building features are incorporated into the design process, the lower the cost.

In a 2000 report on green building cost Bordass motivated that if the triple bottom line of economic, human and environmental costs and benefits are considered when making green building investments, the overall investment for the owner does not amount to a cost premium over and above the cost of non-green buildings (2000: 338).

Lucuik et al in a study for Industry Canada (2005) on local green building cost confirmed a cost premium paid for green initiatives, mainly due to design cost and innovative and non-standard materials. Long-term cost benefits however were expected to outweigh the initial cost premium. Owen et al (2006) also highlighting the increased up front cost of green building due to design cost associate with achieving green building ratings. Cupido, et al (2010) confirmed these findings.

Peter Morris in a study for Davis Langdon also agreed that the increase in first cost was the major challenge to include green elements in building designs. Participants opposing green buildings suggested a cost premium of up to 30% and more but actual case study information indicate a much smaller cost premium (2007: 55). Rawlinson (2007) in another Davis Langdon study found that BREEAM buildings in the
United Kingdom (UK) had an average cost premium of 6%. A Singapore study by Hwang and Tan (2012) also agreed that the perceived cost premiums remain the hindrance to the uptake of green buildings.

An international study by (Kats, 2010) confirmed that despite numerous studies and business cases the perceived cost premiums still remains the main concern. Green building cost premiums of up to 12.5% in Australia and 17% in the US were still expected by industry professionals. However the actual average cost premiums of 1.5% were far lower. A 2013 study by Rehm & Ade to summarize the findings of 4 different US studies on green building cost, found that from a total of 1546 US real estate professionals only 1% expect green buildings to cost less than conventional buildings with 3% expecting the same cost for green buildings. The remaining 90% of respondents expected the following green cost premium: 31% or respondents expected a premium of 1-5%, 27% of respondents expected a 6-10% premium with the remaining 27% expecting a premium of more than 10% (2013, 200).

With regards to cost control Matthiessen & Morris (2007) noted that even in times of rising cost in the US, green buildings were often completed within budget. Rehm & Ade (2013: 207) in the first in-depth study into green construction cost in New Zealand (NZ) confirmed the findings of Matthiessen & Morris in the US. Many of the NZ buildings were completed within budgeted cost.

### 3.2 Correlation of cost premiums with green building rating level

Lucuik et al (2005) found a positive correlation between the level of green ratings and the capital cost premium. Building types and sites also affected the cost premium paid for green design. Another Davis Langdon report (2007) on the cost of Australian Green Star buildings, supported the correlation found by Lucuik et al. This study found the following green building cost premium: 4 Star Green Star: 0%; 5 Star Green Star: 3-5%; 6 Star Green Star: 9-11% and more (Milne, 2012: 100).

The 2013 study by Rehm & Ade also reported that the positive correlation between green cost premium and green building rating level was confirmed by the perceptions of New Zealand industry professionals participating in green developments as detailed in Figure 1.

![Figure 1](image-url)
Milne (2012: 16) confirmed that scepticism still persist in the South African commercial property industry about the perceived cost of initiating, building, procuring and operating green buildings. A compelling business case for green buildings in South Africa still needs to be developed, reinforced and communicated to stakeholders. Milne continued that developers expecting a cost premium of 10-15% will tend to favour a short term view on sustainable buildings and will probably decide that the capital premium for developers is not worth-while. Such developers will most probably refrain from pursuing green developments (2012: 76).

3.3. Mature markets and diminishing cost premiums

The 2007 Davis Langdon report argued that as green markets mature, sustainable materials and systems will becoming more affordable and acceptable (2007: 55). Milne agreed that the concept of a maturing green industry should also hold true for the South African green industry. She conceded that global trends have indicated that green buildings will attract a small cost premium above the cost of standard construction. However as young green building markets like South Africa mature and green building practices become more prevalent, these cost premiums tend to decrease or disappear (2012: 17).

Milne (2012, 9) also referred to the Green Building Council of Australia’s (GBCA) study “Dollars and Sense of Green Buildings” that indicated a diminishing effect of the green cost premium. The GBCA report confirmed a cost premium in 2006 when less than 10 certified green buildings existed with another 44 buildings registered for adjudication. By 2008, with more than 68 buildings certified and 400 registered for certification, the issue of green premiums had diminished.

The international green building market is much more mature than the South African market. The GBCSA in a 2012 report emphasised that the small number of green rated buildings in South Africa at that time did not allow for broad evidence on the economics of green buildings. More mature green markets such as the US, UK and Australia has well documented studies into the cost and benefits of green buildings. However, due to the immaturity of the South African market relatively few case studies are available. This aspect was predicted to continue evolving as the South African market matures (Milne, 2012, pp. 13).

A WGBC report (2013) summarised various international studies published between 2000 and 2012 on a wide variety of building types from the US, UK, Australia, Singapore and Israel on green building cost that included actual design and construction cost. These studies indicated green cost premiums of between 0.4% and 12%. The WGBC report (2013, 28) also adds that international studies indicates that construction cost premiums tend to diminishing as markets mature (see Figure 2). However perceptions regarding the high cost for green buildings continue to present a challenge to the development industry.
The GBCSA acknowledges that in immature markets like the South Africa market, premiums do exist and argue that this will diminish as green initiatives becomes more widely accepted, professionals get more experience and building tenants and owners begin to demand these value adding features (Milne, 2012, pp. 100).

3.4 Green building benefits

Many role players have reached consensus on the social and environmental benefits of green buildings, but there is a lack of accurate and thorough financial and economic supporting information. The WGBC conceded that green buildings have been well documented regarding its environmental benefits, but the documentation of the economic benefits it poses to developers is lagged behind (WGBC, 2013: 15).

The 2013 research report of the WGBC clearly motivates many compelling benefits associated with building green for different stakeholders throughout the building life cycle. Yet the issue of controversy remains whether the benefits green buildings has to offer will attract a higher market value to green buildings (WGBC, 2013: 6).

The diverse nature of the benefits of green building must be translated into economic realities to create a better understanding as to who pays and who gains in the green development process. The South African green industry is to some extent still lacking the full understanding of the principals of green buildings with a specific lack attached to the value of the long term benefits of green buildings and the short term cost expenditure (Milne, 2012: 94).

3.5 Life cycle costing

In an early report on green building cost Bartlett and Howard (2000: 315) urged that construction professionals need to consider the whole life cost and environmental impact of buildings and assist key stakeholders to make more sustainable choices. In his 2003 study on green buildings cost Kats argues
that a life cycle cost methodology rather than a consideration of only upfront cost to be applied to make green building decisions. Savings on operating cost may far exceed the additional upfront cost. Green developments can be delivered at comparable prices to conventional buildings and these cost premiums can be recouped via operational cost savings. (2003a, 12). Earlier studies (Cole, 2000; Marlin, 2000) had already proposed that full operating cost and life cycle costing should be used to evaluate green building investment decisions. In support of Kats the WGBC proposed that whole life cycle cost must be considered at the initial design stage of a development to realise the long term value and return on investment of green building (WGBC, 2013:10).

4. A BUSINESS CASE FOR GREEN BUILDING

Milne argues that although various findings indicate cost premiums for green buildings as oppose to conventional buildings, there are strong arguments that green buildings are more sustainable and will probably achieve higher investment returns that should outweighs the additional initial premium of the building (2012, 8). By 2012 the South African green industry was still too immature for such a study. Milne however referred to some proponents of green building who 2012 were so convinced of the business case for green building that they predict that in the near future no premium commercial office building will be developed unless it aims for a green star rating (Milne, 2012: 22).

Green buildings do deliver a suite of financial and environmental benefits which conventional buildings do not. Some elements like savings in water and electricity usage can easily be quantified. The green building market’s focus will start to shift to the asset value, returns receivable and the operational benefits for developers and investors (Milne, 2012: 17).

4.1 International green building performance

Eichholtz et al (2010) considered 21,000 rentals and 6,000 sales transactions to evaluate the correlation between green buildings and their return on investment and property values. This report found that rentals in green buildings were between 2.1% - 5.8% higher than that of similar conventional buildings. The total effective rentals received increased by 5.9% - 6.6% for green buildings while green buildings attained a market value premium of 11.1% - 13%. The report also indicated that green building returns were less sensitive to recent down turns in the property market compared to similar non-green buildings. Another report by the Australian Property Institute (2011) called “Building better returns – A Study of the Financial Performance of Green Office Buildings in Australia” was released in September 2011 and confirmed green rental premiums of 5% and value premiums of 12%.

The Investment Property Databank (IPD) in conjunction with the Property Council of Australia (PCA) launched the PCAIPD Green Investment Index in 2011 to quantify the investment performance of green buildings with environmental ratings compared to non-rated buildings. Buildings with a Green Star certification outperformed the annualised 2 year return of non-rated buildings by 4% as measured at December 2010. 4 Star Green rated buildings outperformed the non-rated buildings by 7.1% (Milne, 2012: 63). Milne stressed that such broad-based studies will be vital to maintain and expand the growth of green building in South Africa (2012, 62) The young South African green industry have grown significantly in the period 2013 – 2015 and may indeed now be ready for similar studies to build and support the business case for green building.
4.2 South African green building performance

The IPD South Africa Annual Green Property indicators track the performance of properties with top quartile energy efficiency performance against the remainder of the IPD property portfolio. The IPC 2014 database consisted of 597 properties from all property sectors with total gross lettable area of 7,586,520 m² and a total capital value of R120.9b. The 2014 IPD report indicated that the top quartile properties were 32.6% more energy efficient using 162.7 kWh/m² annually compared to 241.4 kWh/m² for the remainder of the portfolio. Total annual returns for top quartile properties were 28.7% higher at 12.1% compared to 9.4% for the remaining properties. Average vacancy rates of the top quartile properties were 14.8% lower at 4.6% compared to 5.4% for the remainder of the portfolio. However due to the higher capital value of top quartile performers their Cost to Income ratio of 34.7 is very similar to that of the remainder of the portfolio of 34.4 (2014: 1,2).

The South African green building market may now be reaching the maturity level where the effect of green buildings asset returns and values can be ascertained. However the lower operating cost and increase net income of local green buildings can logically be assumed to result in higher valuations. Ultimately the higher rental should drive the demand for and value of green property according to Trevor King, Property Valuation manager at the Old Mutual Investment group. (Email interview with Trevor King, Property Valuation Manager at Old Mutual. Milne, 2012, pp. 63).

However the valuation industry relies on past evidence to determine the appropriate capitalization rate for a proper valuation, South Africa has a long way to go until they have substantial information to highlight the benefits of green buildings (Milne, 2012, pp. 76).

4.3 Driving forces of green development

The MSCI December 2014 report “South African REITs: The Green Property Investment Wave” stated that acceptance of Green Building practises is driven by three drivers – the regulatory environment, volatility of energy prices and awareness of stakeholders. If all three drivers are working in unison, the synergy creates a “green wave” that may rapidly change an industry from a brown industry with niches that pay a green premium to a green industry also containing brown discounts (2014: 1,2).

The MSCI report (2014: 2) motivated this statement by referring to countries in the European Union, Australia, New Zealand and Japan that are all experience energy price escalation of 7-11% year on year. All countries have strict regulatory frameworks with energy efficiency incentives. An average of 20% of the portfolio of REIT’s in these countries is now green certified buildings. By contrast a country such as the US with energy escalation of only 2% year on year and a lax regulatory environment only has on average 7% green properties in the portfolios of REIT’s.

The MSCI report noted that South Africa's REIT's portion of green properties is very low by comparison in spite of very high year on year escalation of energy prices. The main reason suggested for this is situation is the lack of awareness amongst local property owners and tenants of the business case for green building. Prominent South African stakeholders confirmed that green buildings are still considered as exclusive and are often driven by international tenants. The biggest challenge for the green industry are for the greening of the almost 98% of South African REIT’s that consist of existing non-green buildings.
One of the main factors delaying this refurbishment process is the lack of demand for green office space from tenants renting in non-green buildings (2014: 2).

5. METHODOLOGY

The study is limited to South African green buildings. This study considered the opinions of construction industry stakeholders on the economic benefits of green buildings for developers and property owners in South Africa. Four disciplines of real estate professionals (project managers, architects, quantity surveyors and developers) directly involved with green building design decision were selected to participate in the study. A selection of these professionals active in the commercial property sector from the Gauteng Province of South Africa was targeted for the study survey. A total of 80 respondents were provided with a study questionnaire and 64 respondents returned completed questionnaires.

The study applied a qualitative research methodology with data obtained by means of a Lickert scale based questionnaire containing 13 questions. Due care was taken to test the questionnaire for consistency and user friendliness.

The questionnaire started with an enquiry to profile respondents. The profile will assist with describing the study findings. The questionnaire then asked for respondents’ opinion on green building in general, on the cost of green buildings and on the economic value of green buildings in South Africa.

To enable statistical analysis of the data, the findings on some questions were quantified by allocating the following values to answers: Absolutely disagree – 1; Disagree – 2; Neutral – 3; Agree – 4 and Absolutely agree -5. If for instance the opinion of respondents for a specific question was calculated as an average value of 3.8 (out of a maximum of 5), the opinion will be regarded as indicating relative strong agreement with the question. An average value of 4.5 will indicate very strong agreement while a value of 1.8 will be regarded as relatively strong disagreement.

6. FINDINGS

6.1 Respondent profile

Completed questionnaires were returned by 21 (32,8%) quantity surveyors, 16 (25%) project managers, 14 (21,9%) developers and 13 (20,3%) architects. The questionnaire data indicated the following on years of professional experience of respondents:

0 – 5 years (20,3%); 6 – 10 years (28,1%); 11 – 15 years (6,3%) and 16+ years (45,3%).

The respondents therefore possessed of a relative wide spread of experience. More than half of respondents had more than 10 years of industry experience in their respective fields. More than 98,4% or respondents had a post school qualification and more than 56% of the respondents had a post graduate degree in their respective fields. Figure 3 details the qualification level of the four disciplines role players.
The above findings indicate that the respondents can be described as reasonably experienced and well educated real estate professionals. Their opinions should therefore give a far indication of the status quo of knowledge and convictions in the green building industry of South Africa.

6.2 General view on green buildings

Although the South African green industry is relatively immature compared to the UK and US, only 7.8% of respondents indicate being unaware of developments in the green building industry locally and aboard. Figure 4 indicates that more than 59% regard themselves as informed in this regard.
The different disciplines (see Figure 5) also displayed a very similar knowledge about green building with average values for all four disciplines of between 3.6 and 3.9 (out of five).

Figure 5 - Role players’ awareness of green developments

6.3 Economic benefits of Green building

The statement that green buildings are currently economically beneficial to developers received divided response with 34.4% of respondents disagreeing, 28.1% being neutral, 32.8% agreeing and 4.7% Strongly agreeing (see Figure 6). The average score was 3.1 out of 5 confirming the neutral opinion on this issue. All four disciplines scored between 3 and 3.3. The neutral opinion of the group therefore also extends to all disciplines. This finding means that more than 60% of respondents did not agree that green building is currently of benefit to developers.

In contrast to this finding more than 70% of respondents agreed that green buildings will be economically beneficial to developers in 5 years’ time (see Figure 6). The average score was 3.7 of 5 which confirmed a more positive opinion of real estate professionals on the future benefit of green building. All various disciplines were of similar conviction with average scores of the groups varying between 3.6 and 3.8. This finding strongly correlates with various studies referred to in the literature review that found a trend of diminishing green cost and increased green returns in more mature green markets.
6.4 Cost of Green building

More than 92% of real estate professionals agreed that green building attracts a cost premium over the cost of conventional buildings (see Figure 7). Respondents also were of the opinion that there exists a definite correlation between the Star grading level of a green building and the size of premium the building will attract.

Figure 6 - Green building being economically beneficial to developers

Figure 7 - Green building will attract a cost premium above the cost of conventional building
A total of 61.7% of respondents expected a 4 Star building to attract a cost premium of 0 – 5%. Only 9.8% of respondents were of opinion that a 5 Star building will attract a similar premium and none of them were of opinion that a 6 Star building will have a cost premium of less than 5%.

Only 13.1% of respondents expected a 4 Star building to attract a cost premium of more that 7.5% while 49.1% were of opinion that a 5 Star building will attract a premium of more than 7.5%. For a 6 Star building as many as 94.8% of respondents expected a cost premium of more than 7.5% and 67.2% expected a cost premium of more than 10%. The average cost premium expected was 7.4% while the cost premiums for the different levels of green buildings were 4.5% (4 Star), 7.5% (5 Star) and 10.3% (6 Star) respectively (see Figure 8). This finding corresponded with the literature study where different previous studies have found a positive correlation between the green cost premium and the green building rating level.

![Figure 8 – Expected cost premium of different levels of green building certification](image)

6.5 Higher market value of green buildings

This study also enquired about aspects that may affect the future market value of green buildings such as rental premiums, tax incentives or lower operating costs. For the business case of green building to make sense, the future value of green buildings must also benefit from the cost premium invested during the construction phase. Figure 9 indicates that 75.0% of respondents agreed that South African green buildings will retain a higher market value than conventional buildings. This finding can be interpreted as respondents’ interpretations or expectations of future value as the South African green industry is still too immature for more conclusive proof.
Developers’ comments indicated that green developments are often done to future proof their real estate assets. Market demand driven by international tenants who demand green buildings to fit their corporate images is also supporting green developments. The 2014 MSCI report also confirmed this trend (2014: 2).

The respondents were then asked to respond to the statement that the expected increase in market value will be sufficient to offset the additional capital cost premium. A total of 67.2% of respondents agreed with the statement and only 7.9% did not agree (see Figure 10).
The questionnaire concluded with statements on factors that will increase green building market value. These statements received the following response as detailed in Figure 11:

Lower operating cost - 90.6% of respondents agreed that this will increase green building's market value and only 3.8% disagreed. The average score of 4.3 out of 5 confirmed the respondents' firm belief in operating cost as a major contributor towards increase market value of green buildings.

Higher rentals – 67.4% of respondents agreed that this will increase green building's market value while 11.6% disagreed. The average score of 3.7 out of 5 confirmed that the respondents expect that higher rentals may have some positive effect towards increase market value of green buildings.

Lower vacancy factor – only 25.5% of respondents agreed that a lower vacancy factor will increase green building market value. However only 23.6% of respondents disagreed with the statement. A total of 51.0% were unsure about this aspect. This finding indicates that more information on the different aspects of the business case of green buildings may be required to educate and empower stakeholders.

7. CONCLUSION

The respondents that participated in the study consisted of an evenly and representative spread of four disciplines of construction professionals directly involved with design decision making. Respondents were suitably experienced and educated for their opinions to be regarded as relevant and representative.

A total of 92% of respondents agreed that green buildings will attract a cost premium. The average cost premium expected was calculated at 7.4%. This finding corresponds with the findings of many international studies reported in the literature review for the period of 2003 to 2014, the majority of which found a wide spread agreement on the occurrence of a green building cost premium of between 1 – 104%.

The respondents expected the cost premium to increase with an increase in the level of green building
certification. A 4 Star Green Star SA building was expected to accrue a 4.5% cost premium; a 5 Star Green Star SA building to accrue a 7.5% cost premium and a 6 Star Green Star SA building to accrue a 10.3% cost premium. Again these findings very closely correspond with the findings of international studies reported on.

Respondents also were of opinion that the economic performance of green buildings will increase in the near future when the local green industry will be more mature. A total of 38% of respondents indicated that green buildings are currently of economic benefit to developers while in 5 years’ time that portion increased to 71%. This finding is also in keeping with various international studies referred to that indicated a trend of green cost premiums to decrease and market value premiums to increase as green markets mature.

A majority of 75% of respondents agreed that green buildings will retain an increased market value compared to conventional buildings while 67% expected this increased market value to be sufficient to offset the initial cost premium. The increased market value was expected as a result of lower operating cost (90.6% of respondents) and of increased rental income (67.4% of respondents). Again this finding agrees with international trends of green buildings often returning superior economic performance compared to non-green buildings.

The majority of 60% of respondents indicated awareness of green building developments. In contrast to this the literature seem to indicate that greater awareness of sustainability issues and of the business case of green buildings is needed to stimulate the demand for rental space in South African green buildings. A possible supposition of this finding in the study is that the different stakeholders of the South African green industry possess of varying degrees of knowledge about green issues. The real challenge for the local green industry may be to educate the tenants occupying space in non-green buildings of the need and benefits of renting space in green buildings.

This study has provided several insights into the current perceptions of South African green building stakeholders with regards to the status of the industry and the economic performance expected from green buildings. The findings of the study also confirmed that regardless of the relative immaturity of the local green industry compared to some first world green industries, the South African green industry follows most of the international green building trends.

8. RECOMMENDATIONS

Various other research opportunities arose from this study and the following aspects are recommended for further study:

1. Analyse and describe the trends in the South African green building cost premium as the industry grows into maturity;

2. Describe the primary drivers of South African green building cost premiums;

3. Analyse and describe the awareness of the business case of green building amongst South African commercial tenants;
4. Compare the South African construction industry regulatory framework for energy efficiency/green buildings with that of international peers, given the maturity status of each industry.

5. Describe the factors used internationally to determine the increased market value of green buildings and will the same apply to South Africa;

6. What would be the main drivers for the market value increase? Lower operating cost, higher asset value, higher rentals and occupancy or a combination of these and other

7. What reasons are driving green development – is it tenant driven or future proofing of asset performance by developers?

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Post-project reviews in Nigerian construction industry: the barriers and benefits

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ABSTRACT

Purpose of this paper

Post-Project Reviews (PPRs) are a rich source of knowledge transfer and provide useful insights and opportunities to learn from what previous projects missed. The paper aims at evaluating the benefits of post project review within the Nigerian construction industry with an attempt to reducing the barriers hindering the implementation of such review.

Design/methodology/approach

Primary data were collected using survey approach through well-structured questionnaire which were administered to the stakeholders’ involved on M I Wushishi 500 housing units in Minna, to elicit information as regards their perception of PPRs. After transcribing their opinions, the data was subjected to analysis using descriptive statistics.

Findings

The result of the analysis showed that time and budget restrictions, organizational culture and lack of management support are the major barriers to the PPRs. The research also indicated that PPRs improves quality of work, facilitates collective learning and avoid repeating same mistake in future projects.

Originality/value of paper

It was indicated that PPR should be made a requirement by educating on the potential benefits of the review in mitigating the potential drawbacks and making it a required document during prequalification and selection of contractors. This will assist Government, clients, contractors and public procurements
officers in appreciating and have full understanding of PPRs in enhancing project performance.

**Keywords:** Post-Project Review, Nigeria, Construction Industry, Benefits, Barriers

1.0 INTRODUCTION

The Nigerian Construction industry (NCI) plays an important and dynamic role in the process of sustainable economic growth and development of the country as revealed by statistics and more than 50% of the gross fixed capital budget in Nigeria normally takes the form of construction output which conforms to 35% to 40% of capital formation that is typical of a developed economy (Wase, 2004; Saka and Lowe, 2010). Saka and Lowe (2010) reported that the Nigerian Construction Industry contribution to Gross Domestic Product grow steadily from 1960s to late 1970s where highest contribution (20%) was experienced. They argued further that contribution of construction sector to the GDP however significantly declined to an average of 4% in the late 1980s and 1990s. The GDP has decreased to 1.27% in 2007 according to Federal Bureau of Statistics as cited in Oyewobi and Ogunsemi (2010). The trend over the years is as shown in Figure 1.

![Figure 1: Shows the contribution of Nigerian construction industry to GDP over the years](image)

Building industry (a sub-sector of the NCI) is the most complex of all the industries in Nigeria economy today (Akindoyeni, 2002). The basis of its complexity is not only on the fact that all other industries (whether small scale or large scale) and sectors of the social-economy depend on it for the environment in which they operate but also as a result of its operational requirements. Over the last two decades, the performance of the industry has been dwindling owing to many factors chief among this is the inability to learn from mistakes committed from previously executed projects to better future projects.

On few occasions when PPRs are conducted, the reports are kept in the archive if it is drafted at all, not
accessed by many who could benefit from them. PPRs are meant to reveal the mistakes and how to remedy these mishaps through the reports which attempt to document the project experience both good and bad. It is a truism that collective analysis of the reports may expose important detail, such as recurring problems and good practice on many previously executed projects. Choudhary et al. (2009) submitted further that, most companies or construction firms do not have the resources to thoroughly examine PPR reports, either individually or collectively, important insights and opportunities to learn from previous projects are missed.

Zhang and Iyer (2007) explained that the concept of a Post-Project Reviews analysis is not very straightforward this is because it seems to be a fairly versatile tool but can be put into use to improve the end product of the project. Many authors have come into general agreement about the essentials of PPRs most especially in the software industry (Glass, 2001; Birk et al., 2002; Ewusi-Mensah, 2003; Verner and Evanco, 2005), but still they are given required attention (Verner and Evanco, 2005). Choudhary et al. (2009) viewed Post-Project Reviews (PPRs) to be a rich source of knowledge and data for organisations to learn lessons to improve their future projects but submitted that only if organisations have the time and resources to analyse them.

Due to huge infrastructure deficit the country has experienced, to bridge this gap, it is commissioning new projects. Whenever a new project is commissioned, it would be very helpful if lessons learned from previous but similar projects could be quickly identified to reduce the chances of the same errors or mistakes being repeated and thus, increase the potential for savings in time, cost and improve the quality. To achieve these, it becomes necessary to appraise the PPRs concept in NCI to make known the benefits that could be derived from it, the potential barriers and how it could be made a requirement during pre-qualification of contractors to reduce the sorry situation the industry is tilting towards.

**2.0 WHY PPRs**

PPRs could be seen as a formal arrangement to evaluate projects either during the execution phase (interim evaluation) or after projects’ completion to thoroughly examine and identify errors or mistakes that make projects fail, so that lessons learned or experienced gathered is made beneficial to future projects. PPRs remained the most widely adopted approach most especially in the industry to transfer knowledge from one project team to another teams and also, Orange et al. (1999) and Kamara et al. (2003) recognised that PPRs have massive potential for much more thorough abuse. PPRs is done for so many reasons amongst which are: to enhance clarity of the collective goals; to identify those inhibitors or barriers that prevent them from reaching their goals and possibly militate against or remove them; to put in place enablers that assist them in attaining the projects goal; to measure and monitor progress, to ensure the goals are achieved through identification of errors or mistakes with appropriate remedial actions.

**3.0 STAGES OF PPRs**

Anbari et al. (2008) explained PPR process by leaning on the (Project Management Institute, 2004) PM-BOK Guide using project management process. Their explanations depict that PPR teams should be formed at the commencement of construction projects but this study identified five stages of team building as postulated by (Tuckman, 1965; Tuckman & Jensen, 1977) and these were adapted to develop
lessons learned process of projects in progress or completed, they are tailored towards Tuckman's famed five-stage schema (1965):

**Forming**

As in the first stages of team building, the forming of the PPR team takes place. This stage is referred to as dialectic argument stage by Busby (1999), the PPR team meets to evaluate either projects in progress (interim evaluation) or completed projects and learns about the errors and problems, and then agrees on how to proffer solution to remedy the situation so that the same mistakes are not repeated in another future projects. Teams members tend to behave quite independently as there are arguments and complain about timing and magnitude of information available to work with. The participants may be encouraged by the fact that they want to solve problems to ensure better performance in future but are normally somewhat uninformed of the issues and objectives of the team. PPR participants are normally at their best behaviour but very focused on themselves as arguments may for or against as there are several stories to why an event went wrong or right (Busby, 1999). Anbari et al. (2008) referred to this stage as ‘the initiating process group’ during which the project team is formed to highlights the project charter that will provide the platform for the project to start. Their PPR process models therefore, viewed the stage as where the criteria for measuring project success or failure are identified. Their argument was based on triple constraint theory developed by (Project Management Institute, 2004) and the underling variables were divided into explicit and implicit constraints.

**Storming**

During storming stage, every team member enters the storming stage, in which different ideas compete for consideration. A lot of retrospection takes place here, a true reflection on the past projects or decision means success. Every team member recall their interactions either with the project manager or the client, and try to address issues such as, identifying the challenges that inhibited successful deliveries of projects, what problems they are really supposed to solve, how they will function independently as an individual and collectively as a group. Team members open up to each other and confront each other’s ideas and perspectives with objectivity.

**Norming**

At some point, the team may enter the norming stage. PPR members adjust their behaviour, drop egoism and appreciate individual differences so that they can develop work habits that make teamwork seems more natural and fluid. Team members often work through this stage by agreeing on terms of reference, rules, values, professional behaviour, shared methods and working tools. During this phase, team members begin to trust each other. Motivation increases as the team gets more acquainted with the projects but involve some simulations as to what happens if A is employed and not B and vice versa. This stage witnesses both diagnostic and causal reasoning as some participants may prefer working through documents available to arrive at results while many, may be of the opinion that getting problems solved through what was responsible for it is the best option (Busby, 1999).
Performing

Unlike team building, this is the most crucial stage in PPR, the participants who are high-performing teams are able to function as a unit as they find ways to remedy or proffer adequate solutions to the identified challenges to ensure that future projects that are similar in character and approach are done smoothly and effectively without inappropriate conflict of interest. Team members have become inter-dependent and therefore, can carry out individual assessment of themselves and the projects as a whole. By this time they are more motivated and have adequate knowledge of the task saddled with, the participant are much more competent, granted autonomy and able to handle the decision-making process in future projects with reference to the evaluation report. It is expected that all necessary information required to put evaluation reports are harnessed, though dissention is expected and allowed as long as it is channelled through means acceptable to the team and it does not have malicious intent but to have a comprehensive report that is revealing and workable.

Future Developments

(a) Adjourning and Transforming

Adjourning stage involves completing the task and breaking up the team after the submission of the report. Others call it the phase for mourning. A team that lasts may transcend to a transforming phase of achievement. Transformational management can produce major changes in performance through synergy and is considered to be more far-reaching than transactional management

(b) Norming and Re-Norming

An additional stage was added to Norming after Forming and renaming the traditional norming stage re-norming. This addition is designed to reflect that there is a period after Forming where the performance of a team gradually improves and the interference of either the client or other intruders content with that level of performance will prevent a team progressing through the Storming stage to true performance. This puts the emphasis back on the team and leader as the Storming stage must be actively engaged in to succeed – too many ‘diplomats’ or ‘peacemakers’ especially in a leadership role may prevent the team from reaching their full potential.

4.0 BENEFITS OF PPR

Post-Project Reviews (PPRs) are one of the most important and common approaches for the capture of errors committed in projects execution and also to transfer project knowledge. Therefore, benefits derived from conducting PPRs have been highlighted by Busby (1999); Carrillo (2005); Tan et al. (2006) as submitted by Choudhary et al. (2009) and include:

- **Enhancing team learning**: PPRs provide an opportunity for people involved in the project to come together and examine what went right or wrong during the project. The forum for the PPR should provide an atmosphere for knowledge sharing, exchange of ideas, brainstorming, identifying good and bad practices and contributions which will lead to learning.
- **Ensure transferable knowledge**: The outcome of a good PPR process should be knowledge that can be utilised for future projects, but it is often tacit knowledge and therefore can be difficult to reuse.

- **Benefit client organisations**: Review processes should aim to provide greater insight into how assets are managed, and this should help the project organisation to improve its processes and manage its assets better.

- **Better project phase management**: Reviewing each phase of a project provides opportunities for better project management at the phase level, rather than carrying out a single review at the end. Hence, mistakes might be corrected earlier at the phase level perhaps benefiting the remaining project phases (Von Zedtwits, 2002).

- **Prevent knowledge loss**: When a project team disbands, the knowledge carried by the team members can be lost. A PPR process should capture their project related knowledge and make it explicit for others to utilize.

- **Promotes quality**: PPR encourages improved quality and effective decision making process most especially when adopted during the construction phase to reduce reworks or failure of any components of the projects as it gives a clear warning of the effects.

- **Encourages transparency**: It eliminates bottleneck and lack of transparency in the award or acquisition of contracts. When PPR is honesty pursued or executed it enhances the procurement process most importantly in Nigeria where traditional procurement is still much in practice by eliminating the stages that may lead to acrimonious relationship among the stakeholders.

- **Project Success Factors Identification**: Critical success factors and criteria are identified and stated to improve future projects success, if what went right could to success and what went wrong could to failure, then project success should be hinged on what went right.

- **Make Lessons Learned Beneficial**: Lessons Learned from previously executed projects such as identified problems, proffered solutions and experience gained becomes instrument for future projects

- **Enhances brainstorming**: It enhances brainstorming and trading of ideas coming from different projects since no two projects are entirely the same. Therefore, arguments could be aligned to better future projects execution.

- **Identification of root cause of errors**: It uncovers the main causes of mistakes that probably lead to failure to ensure that the same errors are not committed over and over again.

- **Encourages Participants Assessment**: It gingers individualistic assessment of the project participants rather than apportioning blames as good practice mechanism to promote social relationship.

### 5.0 BARRIERS TO PPRs

Busby (1999) reiterated what could be drawbacks to successful implementation of PPRs as follows:

- **It is time consuming**: this is a critical problem in the implementation of projects post-mortem reports as many complain of time constraints and many clients’ are of the opinion that the essence of the PPRs are to ensure that the same mistakes committed in previously executed projects does not raise its ugly face again. Therefore, they find it difficult to allocate cost and appropriate enough time
as it tends to solve future problems and not the immediate challenges except in the case of interim evaluation of projects in progress. Keegan and Turner (2001), Disterer (2008) and Williams (2008) explain that lack of adequate employee time to record the experience gained becomes a major obstacles to inter and intra project learning process

- Lack of continuity: it is widely accepted that lessons learned are only beneficial to future projects and not the one under evaluation, thus encourage the disuse of the reports. Williams (2008) reiterated that there are inherent features within projects that hinders lesson learned chief among these are temporary nature of project (that is having time frame) and projects complexity. It was nonetheless, suggested that this does not connote that all projects are entirely the same or different. Newell et al. (2006) in their research carried out on sharing knowledge across projects with focus on the limits to ICT-led project review practices asserted that though, some projects exhibit certain uniqueness that make them look different from others but method of execution across projects may likely share some feature much in common. This argument was supported by Cooper et al. (2002) in their research which was titled learning to learn, from past to future that this wrong information that projects are unique in its entirety hinders learning rather than the nature of projects itself.

- Mirror the past: many viewed PPRs as backward looking exercise since it involves retrospection of all activities carried out during the execution of the projects in question and the people involved feel bad and get disenchanted about it. This is because it has been seen as a way of apportioning blames and an avenue of pointing accusing fingers at the participants. It becomes interesting when it's forward looking and meant to solve future problems.

- Maintenance of social relationships: maintenance of social cohesion means a lot to people better than analysis of isolated events that may involve allotting blames, criticism and unhealthy reproach which can make participants unwilling to do or partake in the exercise.

- Counting on experience: Many people viewed experience as the best teacher forgetting the fact that without work or lessons learned nothing is experienced. Other includes;

- Lack of technical know-how in carrying out the PPRs

- Lack and inadequacy of reference data which may act as the benchmarks at the project inception phase in relation to the project goals to establish criteria of assessment in a post project review.

- Lack of adequate record of cost and other relevant data required for the exercise during project execution stage.

- Political sponsorship or “godfatherism” to cover up inefficiencies and corruption on the part of the people involved by their refusal to submit required data that can promote smooth evaluations.

- Lack of interim reviews makes the final post review impossible depending on the issues that are characterized the project.

6.0 RESEARCH METHODOLOGY

The research employed survey method in its approach using questionnaire to elicit information as the main tool for collating the opinions of the sample of the professionals who have responsibilities on the target projects based in Minna-Nigeria, the study area. Structured questionnaires were administered to the participants on the projects and the sampling frame was limited to those constructors on the M1
Wushishi Housing estate in Minna-Nigeria. The choice of the project was informed because of the difficulties encountered during the execution phase through to completion and even at post occupancy stage. The project was a laudable project to the Government of the State and it was meant to be the benchmark or standard against which others will be evaluated. The goals were partially achieved in term of cost, time and quality because the buildings were erected but consumed more resources than envisaged. This research becomes necessary when lesson learnt on the project was not captured before the commencement of another 500 housing unit which suffered similar problems and have excess re-work which should have been avoided had lessons learnt were documented. The target population for the research included Government workers who have supervisory roles, the policy makers and professionals handling projects (Consultants and contractors) that were duly registered with the State Government and participated in different projects in the State. Non-probabilistic sample of sixty (60) construction professionals, fifteen (15) policy makers, five (5) from the financier side and twenty (20) government workers who are professionals were administered with the questionnaires. Seventy five (75) numbers of the questionnaires returned by the respondents were considered viable for analysis. The data sourced were analysed using basic descriptive statistics; Mean score, standard deviation, skewness and kurtosis were used to rank the Barriers and Benefits of post project reviews using Statistical Package for Social Sciences (SPSS) and Microsoft Excel 2007.

7.0 RESULTS

The Tables 1-3 showed the mean value, standard deviation as well as skewness and kurtosis results. Curran, West, and Finch (1995) as cited in Bright (2008) suggested that data could be said to be in excellent condition if skewness ranges is fewer than 2 and kurtosis ranges fewer than 7.

Table 1, contains factors relating to barriers to PPRs, time and budget restriction is the most important barrier and was ranked first with mean value 3.940, organizational culture is another barrier with mean value of 3.952 and was ranked second, lack of management support was ranked third with mean value of 3.862, the fourth ranked barrier was expensive in terms of company overhead with mean value of 3.749 and the fifth was lack of maintenance of data during project progress with mean value of 3.692. It was shown in the table that the sixth barrier to post project review was manpower intensive with mean value of 3.583. It was shown in the table that the least barrier to post project review was project inability to reflect on past experiences with the mean value of 2.960 and was ranked twentieth and so other barriers are available with their rankings and mean values in the table.
<table>
<thead>
<tr>
<th>S/NO</th>
<th>Barriers of PPR</th>
<th>MEAN</th>
<th>Rank</th>
<th>SE</th>
<th>SD</th>
<th>SKEWNESS</th>
<th>KURTOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Time and budget restriction</td>
<td>3.940</td>
<td>1</td>
<td>0.155</td>
<td>1.061</td>
<td>-0.716</td>
<td>-0.174</td>
</tr>
<tr>
<td>2</td>
<td>Manpower intensive</td>
<td>3.583</td>
<td>6</td>
<td>0.155</td>
<td>1.280</td>
<td>0.221</td>
<td>-1.550</td>
</tr>
<tr>
<td>3</td>
<td>Expensive in terms of company overhead</td>
<td>3.749</td>
<td>4</td>
<td>0.750</td>
<td>0.218</td>
<td>-0.251</td>
<td>0.750</td>
</tr>
<tr>
<td>4</td>
<td>Poor-team internal communication</td>
<td>3.611</td>
<td>15</td>
<td>1.008</td>
<td>0.981</td>
<td>0.152</td>
<td>1.008</td>
</tr>
<tr>
<td>5</td>
<td>Lack of resources to act on the outcome of the review</td>
<td>2.950</td>
<td>16</td>
<td>1.057</td>
<td>0.752</td>
<td>0.225</td>
<td>1.057</td>
</tr>
<tr>
<td>6</td>
<td>The beneficiaries are future projects</td>
<td>3.990</td>
<td>17</td>
<td>0.750</td>
<td>0.218</td>
<td>-0.251</td>
<td>0.750</td>
</tr>
<tr>
<td>7</td>
<td>Lack of maintenance of data during project progress</td>
<td>3.692</td>
<td>5</td>
<td>0.512</td>
<td>0.981</td>
<td>0.152</td>
<td>0.512</td>
</tr>
<tr>
<td>8</td>
<td>Political patronage to cover up inefficiency and corruption</td>
<td>3.550</td>
<td>18</td>
<td>0.781</td>
<td>0.752</td>
<td>0.225</td>
<td>-0.781</td>
</tr>
<tr>
<td>9</td>
<td>Lack of interim reviews</td>
<td>2.916</td>
<td>14</td>
<td>0.512</td>
<td>0.633</td>
<td>0.750</td>
<td>-0.512</td>
</tr>
<tr>
<td>10</td>
<td>Fast track procurement basis of many construction projects</td>
<td>3.500</td>
<td>7</td>
<td>0.152</td>
<td>0.712</td>
<td>0.108</td>
<td>0.152</td>
</tr>
<tr>
<td>11</td>
<td>Lack of expertise in the subject matter (incompetence to carry out reviews)</td>
<td>3.558</td>
<td>10</td>
<td>0.750</td>
<td>0.218</td>
<td>-0.251</td>
<td>0.750</td>
</tr>
<tr>
<td>12</td>
<td>Inability to reflect on past experiences</td>
<td>3.952</td>
<td>2</td>
<td>0.145</td>
<td>1.330</td>
<td>-0.493</td>
<td>-0.815</td>
</tr>
<tr>
<td>13</td>
<td>Reluctance to blame</td>
<td>3.155</td>
<td>12</td>
<td>0.193</td>
<td>1.250</td>
<td>-0.074</td>
<td>-1.386</td>
</tr>
<tr>
<td>14</td>
<td>Project base nature</td>
<td>3.168</td>
<td>13</td>
<td>0.850</td>
<td>0.110</td>
<td>-0.251</td>
<td>0.751</td>
</tr>
</tbody>
</table>
Table 2, also shows the benefits derivable from PPRs, improvement of quality of work is the most important benefit and was ranked first with mean value 3.990, seconded in ranking is facilitating of collective learning with mean value of 3.891, it also improves utilizable knowledge and this was ranked third with mean value of 3.846. It was revealed in the table that the root cause of errors are identified so they are not repeated is another benefit of post project review which is ranked fourth with mean value of 3.872 and ranked fifth is that it is a powerful way of adding continuous improvement mechanism. Also shown in the table is that post project review help reduce project failure which was ranked sixth and with mean value of 6.762. Other benefits of post project review and their rankings are as shown the table below.

<table>
<thead>
<tr>
<th>S/NO</th>
<th>Benefits of PPR</th>
<th>MEAN</th>
<th>Rank</th>
<th>SE</th>
<th>SD</th>
<th>SKEWNESS</th>
<th>KURTOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Improves quality of work</td>
<td>3.990</td>
<td>1</td>
<td>0.145</td>
<td>0.161</td>
<td>-0.814</td>
<td>-0.184</td>
</tr>
<tr>
<td>2</td>
<td>Facilitating collective learning</td>
<td>3.891</td>
<td>2</td>
<td>0.135</td>
<td>1.230</td>
<td>-0.592</td>
<td>-0.725</td>
</tr>
<tr>
<td>3</td>
<td>It improves utilizable knowledge</td>
<td>3.846</td>
<td>3</td>
<td>0.769</td>
<td>0.378</td>
<td>-0.971</td>
<td>0.169</td>
</tr>
<tr>
<td>4</td>
<td>Benefits client organization</td>
<td>2.895</td>
<td>18</td>
<td>0.630</td>
<td>1.618</td>
<td>1.464</td>
<td>0.546</td>
</tr>
<tr>
<td>5</td>
<td>Cross fertilization of ideas between projects is encouraged</td>
<td>2.990</td>
<td>16</td>
<td>0.811</td>
<td>0.023</td>
<td>-0.0657</td>
<td>0.811</td>
</tr>
<tr>
<td>6</td>
<td>Self-assessment by project staff and wider use of good practice is encouraged</td>
<td>2.941</td>
<td>17</td>
<td>1.258</td>
<td>0.512</td>
<td>0.981</td>
<td>0.152</td>
</tr>
<tr>
<td>7</td>
<td>The accrued past experiences, problems and remedies of others are made readily available to others</td>
<td>3.051</td>
<td>15</td>
<td>1.051</td>
<td>0.781</td>
<td>0.752</td>
<td>0.225</td>
</tr>
<tr>
<td>8</td>
<td>Proposals and strategies are better planned</td>
<td>2.550</td>
<td>20</td>
<td>0.253</td>
<td>0.512</td>
<td>0.633</td>
<td>0.750</td>
</tr>
<tr>
<td>9</td>
<td>The root cause of errors are identified so they are not repeated</td>
<td>3.782</td>
<td>4</td>
<td>0.981</td>
<td>0.152</td>
<td>0.712</td>
<td>0.108</td>
</tr>
<tr>
<td>10</td>
<td>The quality of decision making is enhanced</td>
<td>3.005</td>
<td>14</td>
<td>0.752</td>
<td>0.225</td>
<td>0.456</td>
<td>0.057</td>
</tr>
<tr>
<td>11</td>
<td>It is used to access what went through a project</td>
<td>3.245</td>
<td>13</td>
<td>0.633</td>
<td>0.750</td>
<td>0.218</td>
<td>-0.251</td>
</tr>
<tr>
<td>12</td>
<td>It is a powerful way of adding continuous improvement scheme</td>
<td>3.895</td>
<td>5</td>
<td>0.712</td>
<td>1.008</td>
<td>0.981</td>
<td>0.152</td>
</tr>
<tr>
<td>13</td>
<td>It help improve project success</td>
<td>3.599</td>
<td>7</td>
<td>0.456</td>
<td>1.057</td>
<td>0.752</td>
<td>0.225</td>
</tr>
<tr>
<td>14</td>
<td>It can help reduce project failure</td>
<td>3.762</td>
<td>6</td>
<td>0.218</td>
<td>1.251</td>
<td>0.108</td>
<td>0.152</td>
</tr>
<tr>
<td>15</td>
<td>Better project face management</td>
<td>3.680</td>
<td>9</td>
<td>0.374</td>
<td>1.026</td>
<td>0.057</td>
<td>0.225</td>
</tr>
<tr>
<td>16</td>
<td>Prevents knowledge loss</td>
<td>3.521</td>
<td>8</td>
<td>0.941</td>
<td>-0.510</td>
<td>-0.251</td>
<td>0.750</td>
</tr>
</tbody>
</table>
Table 3, shows the identified concepts of making PPRs a requirement to enhance future performance of projects, educating potential benefits of the review is the most important concept and was ranked first with mean value 3.972. Through legal means post project review can be made mandatory and this was ranked second with mean value of 3.820, making the review cost and resource it as part of the project was ranked third with mean value of 3.782. By mitigating potential drawbacks of post project review, the review can be implemented and was ranked fourth with mean value of 3.585 and also by corporate means which was ranked fifth and mean value of 3.290, the review can be made a requirement and lastly by encouraging interim valuation of the review, the review can be made compulsory.

<table>
<thead>
<tr>
<th>S/NO</th>
<th>Concept of making PPR a requirement</th>
<th>MEAN</th>
<th>Rank</th>
<th>SE</th>
<th>SD</th>
<th>SKEWNESS</th>
<th>KURTOSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>By educating potential benefits</td>
<td>3.972</td>
<td>1</td>
<td>0.145</td>
<td>1.161</td>
<td>-0.814</td>
<td>-0.418</td>
</tr>
<tr>
<td>2</td>
<td>By mitigating potential drawbacks</td>
<td>3.585</td>
<td>4</td>
<td>0.199</td>
<td>1.050</td>
<td>-0.173</td>
<td>-1.266</td>
</tr>
<tr>
<td>3</td>
<td>By making it a compulsory document</td>
<td>3.820</td>
<td>2</td>
<td>0.135</td>
<td>1.230</td>
<td>-0.592</td>
<td>-0.725</td>
</tr>
<tr>
<td>4</td>
<td>By corporate means</td>
<td>3.290</td>
<td>5</td>
<td>0.995</td>
<td>0.950</td>
<td>1.225</td>
<td>0.892</td>
</tr>
<tr>
<td>5</td>
<td>By encouraging interim valuation</td>
<td>3.155</td>
<td>6</td>
<td>0.021</td>
<td>0.999</td>
<td>0.895</td>
<td>0.115</td>
</tr>
<tr>
<td>6</td>
<td>The review should be cost and resourced as part of the project</td>
<td>3.782</td>
<td>3</td>
<td>0.295</td>
<td>0.952</td>
<td>1.180</td>
<td>-1.430</td>
</tr>
</tbody>
</table>

8.0 DISCUSSION OF RESULTS

The research revealed that time and budget restriction was a major barrier to PPRs implementation in the Nigerian construction industry. This was in tune with the findings of Fong and Yip (2006) which reported the main reason why PPRs is not recommended by practitioners was lack of resource and time. Organizational culture is another barrier identified by research which Nelson (2003) regarded as significant predictor of the adoption of PPRs most essentially organization learning orientation. Lack of management support was also precipitated by the study and these may be as a result of so many corrupt practices ranging from usage of inferior materials, collection of kickbacks (Sohail and Cavill, 2009) to 'god fatherism' in contract award processes. There is also difficulties transferring and using of valuable knowledge gained within particular projects by subsequent projects and/or the project-based organiza-
tion as a whole this is because no two projects are entirely the same in characteristics (Bartsch, Ebers, and Maurer, 2012).

Anbari et al. (2008) contended that the belief amongst researchers that PPRs are beneficial is general and as such the benefits of PPRs include but not limited to running low-cost experiments, enhancing organizational change and innovation, and integrating resources across internal organizational boundaries (DeFillippi, 2002). Thus, the research revealed that PPRs leads to an improvement of quality of work which was in line with the opinion of Liu and Yetton (2007) by controlling quality standard, progress and cost. Facilitating of collective learning as viewed by Nelson (2003) and Choudhary (2009) that PPRs provide opportunities for project teams to share and discuss or explains their personal experiences which facilitate interactions before a project is closed and the team is dissolved on one-on-one basis. It also improves utilizable knowledge and revealed that the root causes of errors are identified so that they are not repeated in future (Carrillo, 2005; Tan et al., 2006).

9.0 Conclusion

It is not exaggerating to say that a major problem in the Nigerian construction industry is that lessons are not learned from previous mistakes committed from previously executed projects due to inability to set up meaningful and reasonable post-project review process despite its urgent need. Mistakes are only worthwhile making if you can learn from the experience. The great majority of projects in Nigerian construction industry appear not to be post-reviewed at all, and there are good indications that most post-project reviews are considered as a necessary but not critical exercise.

The research thus concluded; that major barriers to PPRs are time and budget restrictions, poor organizational culture and lack of management support. The benefits of PPRs includes improved quality of work and ability to facilitate collective learning while educating potential beneficiaries of the PPRs was revealed as the most important concept of making post-project review a requirement and also by making it a compulsory document during prequalification.

10.0 Recommendations

The following are the recommendations put forward by the study:

- PPRs should not be conducted for their own sake and that any outcome of post-project review must be an input to a subsequent project
- PPR should be made a requirement by educating on the potential benefits of the review and making it a compulsory document during prequalification and selection of contractors.
- Participants should encourage interim evaluations. Lessons can be learned prior to the completion of a project. Delaying evaluations to the end of the project makes the gathering of information more difficult, particularly for projects of long duration. The lessons learned from interim evaluations may provide an input to the planning of the next phase of the project being reviewed.
- Those who generally participate in the post-project review process should also include “users” of the project deliverables. An objective facilitator should run the process and the review should be cost
and resourced as part of the project. Post project review should be viewed as an integral part of the project and it should be planned for at the outset to ensure maximum pay-off from the review.

- Post project reviews should be made a strict policy of organizations in such a way that post project review becomes a norm compulsory within the firm that yields continuous feedback of project efforts on a regular interim basis.

References


Physical Progress Trend Analysis Based on Earned Schedule Performance – An Owner’s Perspective
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ABSTRACT
Schedule predictability is a recurring topic in many project monitoring and control situations, as it impacts in costs and quality. In an owner’s perspective, the cost and price dichotomy strengthens trend analysis methods based on physical progress. In this scenario, this paper aims to provide a method that identifies and speeds up eventual action plans, improving decision processes.

There are different methods to measure schedule accuracy and performance. However, Earned Value Management System (EVMS, also known as EVM), despite being originally developed as a cost management tool, is the most common one. Developed as a derivative method, Earned Schedule Management decouples schedule and cost performance measures, utilizing duration and physical progress as the main inputs. Therefore, this paper unfolds and details the application of the Earned Schedule Method.

The method is applicable at any project level, based on a schedule performance index in order to create an updated schedule, generating a new critical path, finish dates and physical progress trend curves based on actual performance. This detailing allows the project manager a drill down analysis, who is able to proceed more accurately and better measure action plans results.

The results indicate that not taking actions on identified deviation ends up on schedule impacts according to calculated trend. Also, the method application must be included in the project manager’s meeting schedule and identified highlights must be addressed, as well as follow-ups performed on the field. Additionally, the analysis routine points to opportunities of gains arising from its automation.

The method is primarily applicable on Primavera P6, but may also be used on other project management software.

Trend analysis based on physical progress is a reasonable solution by the owner’s perspective since there are traceable and trustworthy data for analysis. The method provides the actual performance of several ongoing processes (design, procurement, assembly, commissioning) and a more accurate date for future deliverables as long as the performance remains the same until the project’s end. While, the updated schedule should be used to complement deviation and risk analysis.

Keywords: predictability, trend, physical progress, earned schedule.
1 INTRODUCTION

Predictability in time management routine constitutes an important tool to support decision-making processes, aiming to achieve the project’s established planning objectives. Project managers need to sum up progress information of the whole project, report budget and schedule performance, forecast at completion cost and completion date and compare different projects with the same metrics. With different activities having various control methods (weight, length, volume etc.), a common denominator is required. Percentage of budget spent or time elapsed can mislead conclusions about performance as the cost of each work package could differ from planned. Also it is a common situation when the project owner wants to evaluate a project performance whose implementation was contracted to a third party. If it is a global cost contract, the owner will only have the contracted price and not the contractor real cost, possibly causing a distortion in the EVM implementation with the available information.

In contrast, the present Trend Analysis method provides a valuable performance control and schedule predictability based on physical progress.

2 LITERATURE REVIEW

2.1 Earned Value Management

The Earned Value Management (EVM) is a method to measure performance and progress of projects based on the Earned Value (EV) concept. The method performs measurement of project cost performance by comparing EV (planned cost of work performed) and actual cost (AC), and progress measurement by comparing EV with planned value (PV) (PMBOK, 2013).

The cost performance is calculated by the CPI indicator (Cost Performance Index), which is the ratio between EV and AC, as indicated by Equation (1). A CPI index greater than 1 indicates that the cost of the project is under budget for the work performed, thus a CPI lower than 1 indicates otherwise.

\[ CPI = \frac{EV}{AC} \]  \hspace{1cm} (1)

The schedule performance is calculated by the SPI indicator (Schedule Performance Index), which is the ratio between EV and PV as indicated by Equation (2). An SPI greater than 1 indicates that the project cost is greater than planned for the work performed, thus an SPI lower than 1 indicates otherwise.

\[ SPI = \frac{EV}{PV} \]  \hspace{1cm} (2)
Both EVM indexes are extracted from cost information and the relation between them can be observed in Figure 1.

**Figure 1 Earned Value Management**

There are techniques derived from EVM to predict the Estimate At Completion (EAC) total cost of a project that depend on two scenarios: if the project's cost in the future will behave as planned or “as is”. Thus, the total cost is the sum of the actual cost (AC) and estimate to complete (ETC) cost of the remaining work, as shown in Equation (3).

\[
EAC = AC + ETC
\]  

(3)

Assuming that the remaining work will be performed as planned, regardless of the current performance, the ETC will be the result of subtracting the total budget at completion (BAC) cost from EV, as shown in Equation (4).

\[
ETC = BAC - EV
\]  

(4)

If current cost performance affects the remaining work until the project’s end, the CPI will be applied to Equation (4) as a factor, as shown on the Equation (5).

\[
ETC = \frac{(BAC - EV)}{CPI}
\]  

(5)
The equation can also be simplified by dividing the BAC cost by the CPI, as indicated Equation (6).

\[
EAC = \frac{BAC}{CPI}
\]  

(6)

Although CPI was used as a denominator Equation 6, both CPI and SPI could be used. In addition, a variation of this method could be weighting the CPI and SPI at different values (e.g., 80/20, 50/50, or some other ratio) according to the project manager’s judgment.

2.2 Earned Schedule

The Earned Schedule (ES) is a schedule analysis method developed by Lipke (2003) that derives from EVM focusing on time performance and not on cost, as originally defined by the EVM.

For the method application, the planned and actual project cost curves are required. Also, the values involved must be traceable with the established measurement criteria.

ES is the planned time of the actual work. As seen in the EVM, cost is the common variable to measure the project’s work. It can be said that the ES is the planned time of the earned value. This assumption allows the ES to be identified in an S-curve graph as the time interval between the beginning of the planned curve and the time on the planned curve corresponding to the EV.

The Figure 2 shows an example of ES as it indicates planned duration for EV.

Figure 2 Earned Schedule
The time performance calculation is done analogously to the original SPI, however instead of calculating the cost ratio between EV and AC, the time performance is measured by applying a time ratio between ES and actual time (AT). As the ES performance indicator is a function of time, it is called SPI(t), as shown in Equation (7).

\[ SPI(t) = \frac{ES}{AT} \]  (7)

In the Earned Schedule method, an SPI(t) greater than 1 indicates that the actual work took less time than planned, thus the SPI(t) lower than 1 indicates otherwise. For example, an SPI (t) of 0.83 for piping assembly indicates that every elapsed day is equivalent to 0.83 day of the planned curve.

3 METHODOLOGY

EVM and ES use cost to measure the project’s progress and performance, but that application can lead to conclusions that do not reflect the time performance on the field, as shows Vandevoorde and Vanhoucke (2006). To avoid that distortion, the method in this article uses physical progress curves instead of cost curves.

Physical progress curves or physical curves are obtained by the cumulative percentage of physical weight arbitrated to all activities, distributed in time.

To summarize the information into levels that address different dimensions (units, meters, tons, etc.), each level should have a weight (percentage or points), usually based on effort.

Similarly to ES, earned progress (EP), representing the planned duration of the actual physical progress, and elapsed time (ET) are evaluated considering the execution start until the analysis cut-off date. Both are obtained through physical planned and actual progress curves.

From the ratio between these values, as defined on Equation (8), the Planning Effectiveness Index (PEI) is obtained and applied to the planned duration to conclude the remaining physical progress in order to obtain the Trend Physical Progress Curve.

\[ PEI = \frac{EP}{ET} \]  (8)

It is worth mentioning that this index does not represent the productivity of resources applied to activities, but the consistency of the planned and actual duration.

Figure 3 illustrates the application of the method.
The PEI expresses, in terms of planned physical progress, the number of earned days for each elapsed day. For the example in Figure 3, for each elapsed day, 0.75 days were aggregated to the physical progress. Therefore, it is considered that:

- \( \text{PEI} < 1 \): execution using more time than planned;
- \( \text{PEI} = 1 \): execution using the planned time;
- \( \text{PEI} > 1 \): execution using less time than planned.

The analysis evaluates groups of activities with similar planning assumptions reflected in the WBS levels (for example, structures assembly, mechanical equipment installation, pile driving etc.), with the following activities being weighted by the WBS level's respective PEI:

- Not started, but with activities of their group started;
- In progress.

Not started activities within a WBS level without other started activities are not weighted by the PEI, but are part of the analysis to compose the logical network of the schedule.
Additionally, the following considerations apply:

- WBS levels or activities with a less than 5% (five percent) physical progress will be considered not started;
- Activities detailed after baseline approval will have their current planning durations considered, respecting the above conditions.

The results (recalculated activity durations) feedback the analyzed schedule, generating new physical progress curves, critical(s) path(s) and deadlines.

3.1 Trend x Projection

Trend and projection calculations present a prediction of schedule planning variables future results (time, cost, physical implementation, among others), but are based on different factors.

Trend analysis encompasses historical results, considering that there will be no change in the scope execution performance, not taking the impact of action plans into account. Projection considers, in addition to historical results, likely scenarios and goals to be achieved, including mitigation plans and action plans.

3.2 Requirements

The tool used to generate the trend curve was developed in Excel, consisting of a (*.xlsm) (Enabled Workbook for Excel Macro) file extension.

It has as input Primavera P6 schedule export files with (*.xer) extension, and also files containing extension with export tabular data (*.txt) through the Primavera P6 reports.

Some automated routines were developed to carry out standardized data entry and export the information obtained by the model in (*.xls) format to feedback into Primavera P6.

The following requirements must be met by the schedule(s) so that the tool has enough data to generate the desired output:

1. Reference planning (baseline) and current schedule(s) with cut-off date of at least six (6) months of historical data. The longer the elapsed execution time, the more accurate is the result.

2. Same scope for baseline and current schedules.

3. WBS Code values in the baseline and current schedules should be equal to the cut-off level established by the evaluators, allowing the performance evaluation of both plans.

4. WBS levels shall present coherent detail in each deliverable. When not met, this requirement can cre-
ate inconsistency in the comprehensiveness of the analysis for each deliverable (for example, piping fabrication of two deliverables at different WBS levels).

5. Not completed activities that add to the physical schedule progress shall set Duration Type to Fixed Duration & Units or Fixed Units. Thus, when entering a new remaining duration, total Nonlabor Remaining Units will not be affected, what would characterize a reweighting of activities.

6. Use of weighting resource in the baseline and current schedules for planning and execution over time in all activities that add to the scope, representing the physical progress of the baseline and current schedules, respectively;

7. Option Drive activity dates activated for all weighting resource assignment so the resource curve period matches the planning period, avoiding weighting discrepancies.

8. There must not be no resources curve with the first period zeroed associated with the weight resource assignment.

These requirements were established strictly for carrying out the trend curve generation method and do not represent a quality indicator of the planning schedule. However, trend analysis should be made after an evaluation of schedule quality and any eventual need for adjustments. There are several schedule evaluation tools available on the market that can assist the planner during schedule evaluation.

The following topics should be considered:

- Application Settings;
- Data Classification;
- WBS (detailling, consistency etc.);
- Activities/Milestones (settings, detailing, interfaces etc.);
- Structure (use of lags, relationship types, constraints, logic network etc.);
- Resources;
- Physical Weighting.

### 3.2.1 Weighting Resource

The weighting resource is going to determine, in percentage, how much each activity contributes to the overall physical scope of the project.

This is achieved by assigning a $1/unit nonlabor resource to all activities that add to the scope of the project. The project settings described on Figure 4 shall be applied:
These settings ensure that:

(1) None but the weighting resource has associated cost, so the field Schedule % Complete gives you the planned physical progress;

(2) Budgeted Cost and Original Duration store the initially planned resource and time; (3) Schedule update is facilitated, maintaining consistency between the cost of the resource assignment and its price;

(4) Activity duration is not mismatched with the physical progress curve. Otherwise there may be differences between the start and finish of the activity and its physical progress curve;

(5) Duration doesn't change by varying the total cost of the weighting resource and/or weighting resource units doesn't change by varying duration.
Then, each WBS level and activity must be weighted using the column “Est Weight”, as described in Figure 5. This is going to determine how many units from the weighting resource are going to be assigned to each activity.

**Figure 5 Weighting WBS/Activities**

![Figure 5](image)

The weighing resource must be configured as indicated in Figure 6 and assigned to all activities that add to the physical scope.

**Figure 6 Weighting Resource Settings**

![Figure 6](image)
To distribute the weighting resource’s units considering each WBS/activity weight, it must be utilized the Top Down Estimation tool (Figure 7). Depending on the project's size, it is recommended to choose any number of Estimated Units large enough to avoid working with decimals.

Figure 7 Top Down Estimation

Additionally, every assignment must have a resource curve that represents the physical progress of a specific activity. If no resource curve is selected, Primavera P6 will assume it is a linear distribution. The BL Project/Budgeted Nonlabor Units and BL Project/Budgeted Nonlabor Cost fields represent the absolute planned weight of the activity in relation to the project’s total scope.

3.2.2 Physical Progress Measurement

After setting up the weighting resource, the Actual Nonlabor Units, Actual Nonlabor Cost (that represent the absolute weight of executed scope), Nonlabor Units % Complete or Nonlabor Cost % Complete (that represent the actual physical progress) fields must be updated in order to measure physical progress.

The following fields will display planned and remaining values:

- **Remaining Nonlabor Units and Remaining Nonlabor Cost**: absolute weight of the scope to be completed (from the Data Date until the projected finish).

- **Schedule % Complete**: planned physical progress until the Data Date. This item considers Budgeted Nonlabor Cost values only at WBS levels. At activity level, the calculation of the item is based on the percentage of activity duration, considering a linear distribution. For this reason, the physical
progress control using the weighting resource is only consistent at WBS levels. As a result of its calculating criteria, the WBS level of activities that do not contribute to the physical progress will have planned physical progress equal to zero. To analyze planned versus actual values, the Schedule % Complete and Nonlabor Cost % Complete can be compared, respectively, as indicated in Figure 8.

**Figure 8** Planned versus Actual Physical Progress

If there are other Nonlabor resources apart from the weighting resource, the progress must be checked only with Cost fields. The Activity Usage Spreadsheet view can be used to visualize the distributed units/cost.

As activities weight shouldn’t change, Budgeted and At Completion Nonlabor Units/Cost values should always be the same.

The Activity Usage Profile view can be used to visualize the S-curve. The recommended settings are described in Figure 9.

**Figure 9** Activity Usage Profile settings
To view the percentage physical progress, divide the presented data by the total distributed units (whole project or specific WBS), as exemplified in Figure 10.

**Figure 10** View percentage physical progress

---

4 APPLICATION

The application of trend analysis is recommended starting from six (6) months of physical execution, repeating every 3 (three) months until project’s completion.

The implementation workflow is illustrated in Figure 11.

**Figure 11** Implementation Workflow
Based on the method’s application, the new schedule feedbacks the existing one, generating new durations, new float values, new critical path etc.

### 4.1 Results Analysis

The new deadline obtained by the trend analysis should be interpreted as a possibility of anticipation or delay, therefore consisting of a tool to identify threats and opportunities and action needs.

From the trend schedule, analysis based on the results should be performed. Critical path changes should be considered, as well as possible impacts on the project’s final date, with complementary productivity and risk analysis, causes for lower/higher performance and specific action and/or mitigation plans.

In the example of Figure 12, the data is presented in a table view, covering the analyzed WBS levels, their respective Planning Effectiveness Index (PEI), total float and remaining duration variation (days/percentual) between the analyzed schedule and the one obtained in the trend analysis. The “Participation” column identifies the main determinants in future performance based on the remaining scope of each WBS level, weighted by its respective PEI.

![Figure 12 Results Analysis](image)

There should also be evaluated, minimally, the lower WBS levels that had a PEI of:

- Lower than 0.5 or greater than 1.25;

- From 1.2 to 1.25 or 0.5 to 0.85 if the group represents more than 20% (twenty percent) of the remaining scope in relation to its upper level;

In the example of Figure 12, the levels highlighted in gray will be examined.
It must be considered that variations in duration and total float can be caused by:

- Low performance of the WBS level in question;
- Postponement of the finish date of predecessor activities in different WBS levels, according to the example of Figures 13a and 13b. It is noted that the 10-day variation of activity “A1 Activity” (activity “B2 Activity” predecessor) generated an increased duration of the “EAP B” level, even without duration deviation of activities in this level.

**Figure 13a Duration/Float Variation – Original Schedule**

![Duration/Float Variation – Original Schedule](image)

**Figure 13b Duration/Float Variation – Trend Schedule**

![Duration/Float Variation – Trend Schedule](image)

The result can also be analyzed through an S-curve. In the case study of Figure 14, the project starts on Apr/2010, the cut-off date is on Sep/2011. The original planning was for the project to end on Apr/2012, but projections indicated a delay of 5 months. After applying the Trend Analysis Method, the new finish date would be Aug/2013. In this particular case, the actual finish date was Dec/2013, confirming the delay trend based on the performance in the cut-off date.

**Figure 14 Case Study – Industrial Unit Construction**

![Case Study – Industrial Unit Construction](image)
5 CONCLUSION

Based on cases conducted in several other projects, the trend analysis method is a useful management tool to increase predictability by the owner's perspective for the schedule planning routine. Performance indices are obtained for group of related activities (e.g. by discipline or WBS levels), so larger deviation contributors can be highlighted and may be separated to perform a targeted in-depth analysis. Additionally, as the new schedule feedback feedbacks the original planning, deviations are incorporated. With a new critical path, it is possible to identify postponements in future deliverables.

However, the results of the trend analysis should not be considered in isolation as it complements other methods such as productivity and risk analysis.

6 REFERENCES


Project audit and project governance to improve results

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1 mechanical engineer from UFRJ, with Master of Business Administration from IAG PUC / RJ, Graduate in Management Information Systems and an MBA in Management from IAG PUC / RJ. It is certified PMP and SixSigma Lean Green Belt. It has several courses in the area of Quality and Project Management. International experience including systems design developments in Germany. Currently holds the role of Corporate Governance Manager at America Movil Brazil (Embratel, Claro and NET) and is Past President of the PMI Rio, regional PMI (Project Management Institute). It is the coordinator for the ABNT CE Commission 93 which deals with standards in Project Management and participates in the CE Commission 63, which deals with standards in Risk Management; is a visiting professor in the MBA at FGV Project Management (Getulio Vargas Foundation) and IAG / PUC RJ. Co-author of the books “PMO - Project Management Office, in practice Programs and Portfolio” by Brasport publisher and “Management in drops: Book Agiterevisor” Enterprise Project Governance: A Guide to the Successful Management of Projects Across the Organization “Paul Aftor read “by Editora Cengage and C. Dinsmore PMP. Reviewer’s Guide to PMI portfolio Governance, Programs and Projects and representative of Brazil in the development of ISO 21503 - Guidelines for Project Governance Programs and portfolio.

ABSTRACT

The audit process is one of the most important tools to identify improvement issues during the entire life cycle of any process. Unfortunately, this process has been used less in project management. ABNT Special Committee 93, for Portfolio, Programs and Projects Standards development, identified this gap and established an standard to guide the companies to introduce project audit process in the project management environment – ABNT NBR 16277:2014 Auditoria de Projetos. This article will presents some important aspects to apply this guide with the objective to improve the results of the projects and reduce costs. The organizational structures and governance aligned with the governance of portfolio, programs and projects are basic principles to develop right projects in the right way. The project audit process should be constructed establishing correct governance. Audit process is very good understand in quality or financial aspect, but should better develop to project management environment. That is the proposal of this article. This theme is very new but too important to achieve the results of the projects for any organizations.

Keywords: Audit Project; Project Management; Governance; Improve process; reduce costs

1 INTRODUCTION

Organizational sustainability is based on a combination of correct projects, executed properly. Sustainability will depend not only a good strategy, but to implement this strategy effectively. The business success will depend on the effective management of their projects and programs throughout the organization.
Project cost above budget impact profit margins and may reduce the benefits expected by stakeholders. Delay in obtaining acceptance of the project customer can impact the cash flow and apply for funding or supplementary budgets.

Problems with schedules implementation of solutions aimed at increasing business efficiency frustrate the expectations of obtaining the expected benefits of cost reduction, as well as contractual penalties and disputes due to implementation failures, can wreck profit margins and careers.

Some problems commonly found in the projects are listed in Table 1.
Table 1: Main causes of failure in projects.

Source: adapted from VARGAS (2013) and MELO (2012)

<table>
<thead>
<tr>
<th>Goals and objectives established evil</th>
<th>Lack of knowledge of the key points of the project</th>
<th>Insufficient time for project planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of coordination between the parties</td>
<td>Those involved do not have skills</td>
<td>Expectations are not aligned with the reality of the project</td>
</tr>
<tr>
<td>Goals have changed with the progress of the project</td>
<td>Lack of staff participation in decision-making</td>
<td>The training and capacity building unsuitable</td>
</tr>
<tr>
<td>Roles and responsibilities defined evil</td>
<td>Inadequate requirements or vague</td>
<td>High risks in the environment</td>
</tr>
<tr>
<td>A change in the organizational structure of the company</td>
<td>Deadlines and unrealistic tasks</td>
<td>Changes in technology available</td>
</tr>
<tr>
<td>Failure of Communication</td>
<td>Insufficient resources</td>
<td>Developments in prices and deadlines</td>
</tr>
<tr>
<td>The political-economic disadvantage</td>
<td>The estimates of cost and schedule are incorrect</td>
<td>Little understanding of the complexity of the project</td>
</tr>
<tr>
<td>The system of inadequate control</td>
<td>Lack of leadership of the project manager</td>
<td>The financial estimates are poor and incomplete</td>
</tr>
<tr>
<td>The warning signs of the project were ignored</td>
<td>A failure in the control of performance</td>
<td>Bad Decisions</td>
</tr>
<tr>
<td>Lack of motivation of the team and stakeholders</td>
<td>A lack of support within the organization</td>
<td>Lack of understanding of the scope of the project</td>
</tr>
<tr>
<td>Scope creep - disorderly growth of scope</td>
<td>Lack of sponsorship</td>
<td>Excessive optimism</td>
</tr>
<tr>
<td>Thinking that planning is a waste of time</td>
<td>Process of change management is non-existent or poor</td>
<td>Inadequate resources</td>
</tr>
</tbody>
</table>
You can summarize as the primary cause of these problems such as deficiencies in organizational and project governance and applied management model.

The governance involves a set of relationships between management, shareholders and other stakeholders. Through governance mechanisms, an organization determines not only its strategic and operational objectives, but also creates the conditions to ensure that processes, procedures, practices, and appropriate organizational structures are in place to achieve the set objectives and monitor their achievement.

The governance of project management defines these relationships and policies applied to managing multiple projects in an organization. The governance of project management establishes processes and procedures necessary to ensure the proper management of strategic projects.

Organizations have set up governance structures to drive the execution of organizational activities. It sets limits of power, rules of conduct and protocols that organizations use to manage progress towards achieving their strategic goals. This is accomplished by controls designed to maximize delivery value and at the same time minimizing the risks. Organizational governance is the process by which an organization directs and control its operations and strategic activities, and for which responds to the legitimate rights, expectations and desires of its stakeholders. Governance processes ensure that investment decisions are taken to identify opportunities, select initiatives for which funds will be promoted and to achieve performance goals.

The project management model is conducted to ensure that the business objectives and the company’s interests are being satisfied by these projects. This suggests the existence of a connection between the project management practices and business processes of an organization, an alignment that converges to the organization's business performance goals.

Use the audit as an effective project management tool provides a business advantage that can result in the reduction of time, reducing the need for rework on the project and allow forecasts and more reliable economic and financial analysis of project performance.

The purpose of business is the achievement of goals set in strategic planning through better results in deliveries and products. He also concludes that the challenge for organizations is to adapt the guide to the best project management practices in accordance with the organizational culture of the company. The systematic audit will help to identify nonconformities in implementing the project and opportunities for timely improvements in order to act on the effectiveness and efficiency of projects, improving results and stakeholder satisfaction. Corrective and preventive actions resulting from audits will help to keep the project within the agreed terms and to assist in achieving improvements in results.

2 ORGANIZATION GOVERNANCE

The principles of the OECD (ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT) on Organizational Governance were first developed in 1999. The Forum for Financial Stability adopted the principles as one of the twelve key standards for sound financial systems. Therefore, the principles now form the basis of the Organizational Governance strand of
reports on compliance with standards and codes (ROSC - Reports on the Observance of Standards and Codes) of the World Bank / IMF.

“Corporate governance is the system by which organizations are directed, monitored and encouraged, involving the relationships between owners, Board of Directors, Executive Board and supervisory bodies. Good corporate governance practices convert principles into objective recommendations, aligning interests in order to preserve and enhance the value of the organization, facilitating their access to resources and contributing to its longevity “Source: IBGC - Brazilian Institute of Corporate Governance..

The best governance practices are based on transparency, fairness, accountability and corporate responsibility. The decision-making model should contain these principles as a foundation to ensure the best results. Ethics is also included in these principles. Organizations that build their management with governance with these concepts are gaining better results and has better market perception of its management.

**Figure 2: Organizational Governance Components**  
*Source: IBGC*

While project management aims to conduct an effective project, governance of portfolio, program and project aims organizational alignment to meet the established strategies. Organizations become, therefore, a portfolio of projects, the result will be the future point desired by the organization. Successful organizations establish its governance of portfolio, programs and projects integrated to organizational governance. It holds the right project that needs to be done the right way, increasing the value of the business and reducing risk. This may result in great opportunities scenarios as crisis scenarios, because decision-making is well structured by mechanisms that guarantee the right communication at the right time and minimize risks of taking wrong paths. Organizations that support the organizational and governance of projects will be making certain the right projects, aligned to the organization’s strategy.
3 PROJECT GOVERNANCE

The opportunity to investigate the expansion of organizational governance principles in the public and stakeholders coincides with renewed questioning of the performance - or rather the lack of performance - of large capital projects.

A study by the International Programme in Engineering and Construction Management (IMEC) in 2000 [6] revealed that 60 major capital projects, with an average capital value of US $ 1 billion carried out between 1980 and 2000, 18% exceed the costs extensively. It also found that nearly 40% of the projects that were abandoned or restructured after experiencing financial crises.

A form of governance mechanism is required to address the apparent lack of accountability in the performance of projects. The issue of project governance has emerged from this need to develop the necessary mechanisms so that the projects are transparent, achieve their goals and are adhering to the principles of good organizational governance.

The Project Management Governance is included in the areas of Organizational Governance related to project activities. Effective governance of project management seeks to ensure that the project portfolio is aligned with the organization’s strategic objectives, is delivered efficiently and is sustainable. The Project Management Governance also supports that all stakeholders are provided relevant and reliable information at the right time.
3.1 Principles of Project Governance

a) benefits of continuous justification - management of projects should lead and maintain a documented way and with appropriate records, the development of the project in order to achieve results compatible with the sustainability of the organization, from feasibility studies, compliance with legal requirements, fulfillment of contractual obligations and alignment with strategic planning;

b) Accountability - the organization must clearly identify the roles and responsibilities defined for the project management;

c) Strategy - project management must remain permanently aligned with strategic business objectives;

d) Performance - itself and documented methodology, you must identify how it will achieve the expected success and what tools, methods, techniques, devices, tools and processes will be adopted; indicators should be defined and measured at the beginning and constantly evaluated its progress;

e) Compliance - project management must maintain systematically updated to meet the set regulations, contractual obligations and standards related to the project context;

f) Focus - project management should provide sufficient controls to show the dynamics of project management in order to ensure the transparency of decisions and their impacts and documented risks
and the planned and achieved results;

g) Continuous improvement - the project management should be used from project audits to identify, document and apply lessons learned aimed at continuous improvement;

h) Risks - project management must continually take care that risks are properly addressed not to negatively impact the projects and can bring some benefit.

4 AUDIT

Auditing is a careful and systematic examination of activities in a particular organization, whose purpose is to ascertain whether they are in accordance with the planning and the practices previously established, if they were implemented effectively and not appropriate (according) to achieving the objectives.

The audit can be conceptualized as a control element, which has as one of its objectives, the evaluation of the company’s processes and controls. The auditor relies on the system survey, which comprises the plan of organization and political procedures, in order to verify that it offers protection to the assets of the organization and reliability of the information and management evidence. In a second step it is for the auditor, by application of audit tests to evaluate the operational efficiency of the system and verify that there is compliance with the guidelines established by management.

The information needed to evaluate the system are obtained by the auditor through interviews with the organization’s employees, procedures manuals, records or documents etc., being evidenced in organization charts, flowcharts, manuals and assessment questionnaires, which should be periodically reviewed and updated.

The extent and nature of audit tests to be adopted to assess the operational efficiency of the system is substantially influenced by the procedures adopted by the organization. In the specific ways in which the controls are considered weak the auditor should make deeper audit examinations and or extend the length thereof.

Audit evidence is an objective fact, a record, a statement, a document or notice, proving the occurrence of certain activity. The evidence must allow verification and should be relevant to the audit criteria. The evidence is sought, can not be absolute, but sufficient and proper. That is, the elements that embody the auditor’s opinion must be certain, clear and provide you with enough material so that the evidence is sufficient, that is, as a result of the test, the auditor becomes the “moral certainty” of proving the facts they are analyzed.

5 PROJECT AUDIT

The base project audit analysis is based on the continuous application of the “audit cycle analysis (CAA).”
The expected benefits for auditing the projects can be highlighted:

a) Identify the effectiveness of the organizational structure of the project management system;

b) Identify the effectiveness of the project management;

c) Identify the relationship between the limits of authority in decision-making for the project management;

d) Identify the degree of adoption, applicability and effectiveness of policies and strategies used;

e) Identify adherence, applicability and effectiveness of processes, best practices and methodologies used;

f) Identify the adequacy, applicability and effectiveness of the controls used in the project management;

g) To provide clarity of the application of regulatory frameworks relevant to the project;

h) Evaluate the provision of project accounts, according to the audit the applicant’s needs;

i) Identify opportunities for improvement in the management and execution of projects.
5.1 Project Audit Requirements

The audit of the projects should be directed based on fundamental elements of good practice in project management, highlighting:

a) Definition of the project management structure,
   -- must be identified and documented, keeping up to date throughout the project life cycle;

b) policies, processes and methodologies to be used,
   -- are elements that should be documented mandatory before the actual start of the project;

c) authority limits for decision-making,
   -- The documented roles and responsibilities, made before the start of the project and kept up to date throughout the project life cycle;

d) Business case,
   -- must be the instrument used to judge whether the project should continue, and its structure and definite purposes must be approved before the actual start of the project. They must include the customer's requirements. It must be documented, keeping up to date throughout the project life cycle.

6 QUALITY MANAGEMENT

Quality management must be a major concern of companies, whether they are geared to the quality of products or services. The satisfaction of stakeholders is a major challenge and very necessary for the development of organizations and their projects. The path is through Total Quality Management with the best project management practices. The awareness of the quality and recognition of its importance, has the management systems certification indispensable quality for organizations worldwide. The certification of quality and increases the satisfaction and trust of customers, reduce internal costs, increase productivity, improve the image and processes continuously, allows even easier access to new markets. This certification allows the assessment of compliance determined by the organization through internal processes, customer ensuring a product or service designed according to standards, procedures and standards.

An organization that aims to implement a focused management policy for quality is aware that their path should be reevaluated. The same need to implement activities aimed at establishing and maintaining an environment in which people, working together, are able to perform effectively in the pursuit of the goals and missions of the organization.

Quality is a subjective concept that is directly related to perceptions of each individual. Several factors such as culture, mental models, type of product or service, needs and expectations directly influence this definition.
The expansion of quality coverage in organizational activities can also be seen in responsibilities that were added to the area, such as environmental quality and quality of life, ethics and values essential today and object of national and international regulations and various standards.

This means that there is a growing awareness of society in this regard, which requires the emergence of demands and exert additional pressures.

Quality is a spontaneous and intrinsic concept to any use of something tangible situation, whether it relates to relationships involved in providing a service, or perceptions associated with products of intellectual, artistic, emotional and experiential.

Quality, therefore, can be understood as a contractual obligation and is measurable. Throughout a project, metrics can be set to provide vital information about the quality of the process, product, activity or resource. These metrics can be objective, such as meters, and / or subjective, such as qualitative good, average and pleasant.

3.1 Project Quality Management

Regardless of structure, when talking about quality, it is worth noting that the quality management of the project should be directed to both the project management processes and for your final product or service project.

These processes are designed to ensure that the project will be completed with the desired quality, and therefore met customer needs and product requirements. Currently, quality management has the basic concern to avoid failures.

Principles of Project Quality Management:

- Identify the level of acceptable quality for stakeholders;
- Know how to be measured this level of quality, by whom, how and when;
- Ensure the determination of everything necessary so that the level of quality is met;
- Implement and ensure all.

The projects are designed to generate results meet the needs. Who has these needs are stakeholders; They are generally customers, workforce, shareholders, suppliers, communities, regulators and various groups. They are individuals with an interest in the performance of the project or organization, and the environment in which it operates.

The audit tool is also essential for obtaining the expected design quality. Thus, achieving cost reduction, customer satisfaction and better results.
7 CONCLUSION

Organizations that achieve the best results are supported by the best organizational governance practices, it demonstrates management capacity and to reduce downside risks. Organizations that get the best results are supported by its capacity for innovation and transformation, through project management. The combination of best practices in organizational governance and project management, with the implementation of the Project Office as one of the governance of components, enables the sustainability of the growth of the organization for long periods. This may result in great opportunities scenarios as crisis scenarios, because decision making is well structured by mechanisms that guarantee the right communication at the right time and minimize risks of taking wrong paths. Organizations that support the organizational governance and governance of portfolio, programs and projects, will be making certain the right projects.

Projects often have difficulties that must be diagnosed accurately and in a timely manner so that you can ensure success during the execution of the projects. In these cases the implementation of projects audits become the most efficient project performance since anticipate problems such as delays in schedules, rising costs, and wear between the parties involved.

Adopt Governance requires Project Audit actions more holistic and obviously innovative way.

8 REFERENCES


Lodi, João Bosco. Governança Corporativa: o governo da empresa e o conselho de administração. São


Proposed model for dimensioning elements from living areas in a construction site

ABSTRACT

Among the places that compose the construction site, the living area represents the place of workers’ support. And, related to this specific element, there are several standards that aim criteria and minimum areas to ensure the quality of worker’s livingness.

Purpose of this paper

Taking into consideration that the construction site is an element of every engineering work, and whereas each of these works required a different design conception, this paper proposes an automatic model for sizing the element “living area” in a construction site.

Design/methodology/approach

Based on Brazilian standards, the model will be created from an automated spreadsheet in software Microsoft Excel, turning information regarding of minimum areas for each place in automatic calculation method.

Findings and value

In this paper was sought a methodology to simplify the job of the engineer responsible for the works budget, in order to increase assertiveness and accelerate the job of dimensioning areas of this element, thereby ensuring economy and viability of the standard cost.

Research limitations/implications

In terms of limitations, the dimensioning shall be conducted only for the living area element. The other elements, such as administrative and industrial areas, will still need to be designed in the traditional way, and could be addressed in future works.

Originality/value of paper

This paper presents a new and very viable tool to help to design the construction site, to assisting in decision-making and to expediting in the budget planning by an estimated overall budget.

Conclusions: The spreadsheet created, from the possession of simple information of the amount of work-
ers, will allow the dimensioning of the living areas. The use of the worksheet provides time savings, and ensures compliance with the minimum conditions required by Brazilian standards.

**Keywords:** Construction site, living areas, model for dimensioning, automated spreadsheet.

1 INTRODUCTION

Among the sites that make up the construction site, the living area is the area of support for the workers.

Based on the public administration view, the preparation of the estimated budget contemplates the formation of the reference budget of the construction site.

The construction site project is an integral part of the execution of the engineering work, and its construction is quite variable depending on the planning of each builder. Thus, this element presents many difficulties to estimate its cost.

This paper proposes a presentation of a model for calculate living areas of a construction site, all based on Brazilian standards, and aims to assist the engineer responsible to decision-making about the minimum required areas of each installation, and that sustain the benchmark cost of the construction site.

Specifically, the paper has designed to create an automated spreadsheet in MS Excel software containing the dimensioning of each living area, following the Brazilian standards restrictions. The present spreadsheet created will show, as a result, the total built-up area for each element (in m²) inside the living area, calculated from the basic information related to the work by the engineer.

2 CONSTRUCTION SITE - CONTEXT

Every construction of an engineering project requires a large planning. Among the steps necessary to the planning, the construction site is a fundamental and important element, if not the most important, and it deserves careful attention.

Rodrigo Soares and Cardoso (2012, p. 2), in order to illustrate the concept, compare the construction site to a factory where, in this system, the resulting product of the process is the whole enterprise. Thus, consequently, the construction site is the entire physical infrastructure that is necessary for the implementation of a construction project.

To contextualize this “factory works”, it is necessary a brief presentation of the elements of this area, discussed below.

2.1 Construction Site Elements

The construction site generally can be considered distributed into the following constituent elements:
• Living area

Living areas are the areas designed to meet the basic human needs of food, personal hygiene, rest, leisure, living and outpatient, and must be physically separated from operational areas (BRAZIL, 2013; ABNT, 1991, p. 1).

It shall be considered as belonging to the living area the following environments: health facilities; locker room; accommodation; refectory; kitchen; laundry; leisure area, and Clinic.

• Administrative site

The administrative site is responsible for the technical and administrative support for the execution of the work, and thus comprises all the environments necessary for work, but are not directly related to its implementation. They are part of the administrative site the following facilities: technical and administrative offices; laboratories and control technology; surveillance areas; watchtowers; others.

• Industrial site

“The industrial site is intended to provide all the logistical support to the production of the work [...]” (INEA, 2012, p. 59). The facilities that comprise the industrial site are quite variable and depend primarily on the end of the construction product, the size of the work and strategy and business planning. One can mention a few elements that are part of the industrial site: central forms; central frame; concrete plant; crushing plant; asphalt plant; others.

Of the three elements of the construction site, the element that will be treated in this paper will be the living area.

3 CONSTRUCTION OF DIMENSIONING MODEL

3.1 Applied Legislation

Were used in the construction of the spreadsheet, the Brazilian technical standards NR 18, NBR 12284/91 and NR 24, which regulate and set minimum criteria of acceptability for the permanence of workers at the construction site. These rules, in general, aim to ensure minimum conditions of hygiene, health, safety and comfort in the areas of experience of the construction site.

3.2 Methodology for Development of Spreadsheet

The spreadsheet model to estimate areas will be developed in Microsoft Excel 2013 software.

Basically, the sheet was divided into four tabs, 3 main “input data”, “dimensioning” and “summary”.

Among the main, the first tab, “input data” is the step where the sheet operator must provide all the basic information of the work. The second tab, “dimensioning” is the main spreadsheet work, and is where
the last main tab “summary” presented all the calculations for defining the areas of each living area element. And, in the “summary” is the summary of the design, with the definition of the areas calculated for each element and the total built area (to the elements of the living area), according to information released by the engineer.

3.2.1 Spreadsheet “input data”

The tab “input data” is the main spreadsheet to be manipulated by the operator. This sheet that the engineer must submit the essential information to be calculate the living area. Is shown in figure 1 a mirror of the spreadsheet “input data”.

![Figure 1 – Mirror of the tab “Input data”](image)

For entering data in the worksheet is necessary that the engineer responsible for the budget is in possession of the estimate of the number of workers at the peak of the workers (phase of the work with the largest number of employees) and the number of building workers at the construction site. The information should be filled as shown above, separating the work and support workers. Thus, it was considered, for purposes of this study, the following, as workers:

- **WORK**: Employees who are directly linked to the implementation of the work. They are usually employed in hourly wage earner, and has its calculated amounts directly from the unit costs of compositions. Example: bricklayer, carpenter, helper.
SUPPORT: Employees who give the support in the construction work. They are usually employed in monthly wage earner, and they do not have their amounts related to costs of compositions. Example: engineer, surveyor, safety technician at work.

3.2.2 Spreadsheet “dimensioning”

This spreadsheet contains all the calculation memory of the living area installations. There will be calculated automatically, on this tab, the following information to the living area:

- Number of objects that make up the physical installation of each space. Example: number of showers needed in the bathroom.
- Corresponding area of each object that makes up the physical installation of each space. Example: area corresponding to one shower.
- Complementary areas relating to entrances, walls, access and other circulations that makes up the physical space of the premises.
- Overall, in square meters, of each installation.
- Considerations in relation to calculation memory of each item in the spreadsheet.

Figures 2, 3 and 4 shows the mirror sheet “design”.
### BATHROOM AND DRESSING ROOM (MALE)

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Area (m²)</th>
<th>Total</th>
<th>Comment details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slower</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Unit area = 0,90m × 0,90m</td>
</tr>
<tr>
<td>Circulation Slower</td>
<td>-</td>
<td>0,00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Unit area = 0,80m × 0,90m</td>
</tr>
<tr>
<td>Toilet seat</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Unit area = 0,90m × 1,20m</td>
</tr>
<tr>
<td>Wash hand</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Whole area = 0,60m × 0,70m</td>
</tr>
<tr>
<td>Entrance, walls, access and other</td>
<td>-</td>
<td>0,00</td>
<td></td>
<td>Considered area = 100% of the calculated area of the bathroom</td>
</tr>
<tr>
<td>Dressing room</td>
<td></td>
<td>0,00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual lockers</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Dimensions: 0,5 m (width) × 0,8 m (depth) Booking ≥ 2 beds</td>
</tr>
<tr>
<td>Dressing room circulation</td>
<td>-</td>
<td>0,00</td>
<td></td>
<td>Dimensions: 0,5 m (width) × 0,8 m (depth) Booking ≥ 2 beds</td>
</tr>
</tbody>
</table>

**Total Area = 0,00 m²**

---

### BATHROOM AND DRESSING ROOM (FEMALE)

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Area (m²)</th>
<th>Total</th>
<th>Comment details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slower</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Unit area = 0,90m × 0,90m</td>
</tr>
<tr>
<td>Circulation Slower</td>
<td>-</td>
<td>0,00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Unit area = 0,80m × 0,90m</td>
</tr>
<tr>
<td>Toilet seat</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Unit area = 0,90m × 1,20m</td>
</tr>
<tr>
<td>Wash hand</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Whole area = 0,60m × 0,70m</td>
</tr>
<tr>
<td>Entrance, walls, access and other</td>
<td>-</td>
<td>0,00</td>
<td></td>
<td>Considered area = 100% of the calculated area of the bathroom</td>
</tr>
<tr>
<td>Dressing room</td>
<td></td>
<td>0,00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual lockers</td>
<td>0 units</td>
<td>0,00</td>
<td></td>
<td>Dimensions: 0,5 m (width) × 0,8 m (depth) Booking ≥ 2 beds</td>
</tr>
<tr>
<td>Dressing room circulation</td>
<td>-</td>
<td>0,00</td>
<td></td>
<td>Dimensions: 0,5 m (width) × 0,8 m (depth) Booking ≥ 2 beds</td>
</tr>
</tbody>
</table>

**Total Area = 0,00 m²**

---

### REFECTORY AND KITCHEN

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Area (m²)</th>
<th>Total</th>
<th>Comment details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refectory</td>
<td>0 tables</td>
<td>0,00</td>
<td></td>
<td>Calculated from the tab “table areas”</td>
</tr>
<tr>
<td>Kitchen</td>
<td>-</td>
<td>0,00</td>
<td></td>
<td>Ares = 3% of Kitchen</td>
</tr>
<tr>
<td>Food pantry</td>
<td>11%</td>
<td>0,00</td>
<td></td>
<td>Ares = 11% of Kitchen</td>
</tr>
<tr>
<td>Cold chamber</td>
<td>3%</td>
<td>0,00</td>
<td></td>
<td>Ares = 3% of Kitchen</td>
</tr>
<tr>
<td>Pre-Preparation Meat</td>
<td>6%</td>
<td>0,00</td>
<td></td>
<td>Ares = 6% of Kitchen</td>
</tr>
<tr>
<td>Pre-preparation Vegetables</td>
<td>6%</td>
<td>0,00</td>
<td></td>
<td>Ares = 6% of Kitchen</td>
</tr>
<tr>
<td>Pre-preparation Cereal</td>
<td>3%</td>
<td>0,00</td>
<td></td>
<td>Ares = 3% of Kitchen</td>
</tr>
<tr>
<td>Special preparation</td>
<td>11%</td>
<td>0,00</td>
<td></td>
<td>Ares = 11% of Kitchen</td>
</tr>
<tr>
<td>Cooking</td>
<td>15%</td>
<td>0,00</td>
<td></td>
<td>Ares = 15% of Kitchen</td>
</tr>
<tr>
<td>Distribution</td>
<td>10%</td>
<td>0,00</td>
<td></td>
<td>Ares = 10% of Kitchen</td>
</tr>
<tr>
<td>Cleaning and cleaning card</td>
<td>3%</td>
<td>0,00</td>
<td></td>
<td>Ares = 3% of Kitchen</td>
</tr>
</tbody>
</table>

**Total Area = 0,00 m²**
### DIMENSIONING - LIVING AREAS

**Notes:**
1. The calculated area refers to the built area, except the roof.
2. The spreadsheet is limited to 1,600 workers.

#### WORKERS' BUILDING (MALE)

- **Total Area:** 0.00 m²

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Area (m²)</th>
<th>Total</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bedroom (unit 4 workers)</strong></td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td><strong>Dimension:</strong> 2.7m x 3.5m (including walls and partitions)</td>
</tr>
<tr>
<td>Shower</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td>Unit area: 0.90m x 0.90m</td>
</tr>
<tr>
<td>Circulation Shower</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Toilet seat</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Urinal</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Entrance, walls, access and other circulations</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td>Considered area = 80% of the calculated areas of the bedroom.</td>
</tr>
</tbody>
</table>

#### WORKERS' BUILDING (FEMALE)

- **Total Area:** 0.00 m²

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Area (m²)</th>
<th>Total</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bedroom (unit 4 workers)</strong></td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td><strong>Dimension:</strong> 2.7m x 3.5m (including walls and partitions)</td>
</tr>
<tr>
<td>Shower</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td>Unit area: 0.90m x 0.90m</td>
</tr>
<tr>
<td>Circulation Shower</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Toilet seat</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Urinal</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td></td>
</tr>
<tr>
<td>Entrance, walls, access and other circulations</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td>Considered area = 80% of the calculated areas of the bedroom.</td>
</tr>
</tbody>
</table>

#### SUPPORT BUILDING (MALE)

- **Total Area:** 0.00 m²

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Area (m²)</th>
<th>Total</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suite (unit 2 workers)</td>
<td>0 units</td>
<td>0.00 m²</td>
<td>0.00 m²</td>
<td><strong>Dimension:</strong> 3.7m x 4.2m (including walls and partitions)</td>
</tr>
</tbody>
</table>

|--|--|--|--|
3.2.3 Spreadsheet “summary”

This spreadsheet is a summary of the calculated dimensioning, containing the number of installations, the unit area of each and the total area estimated for the living area of the construction site. In figure 5 is shown a mirror of sheet “summary”.

Figure 4 – Mirror of the tab “dimensioning”, page 3
3.3 CONSTRUCTION OF THE WORKSHEET

It will be presented in this section, the design of the used for the construction of the spreadsheet. It was decided that bathroom and dressing room, such as refectory and kitchen, are part of the same installation in the living area. Thus, the sheet divides the living area in the following facilities:

- Bathroom and dressing room;
- Refectory and kitchen;
- Workers’ building;
- Support building;
- Laundry;
- Recreation; and
- Ambulatory.

Each installation described here will be treated individually, and it will be presented in the following items.
3.3.1 Bathroom and dressing room

To build this spreadsheet installation, was carried out with the following steps: (i) definition of the quantities of each object, based on the minimum amounts required by Brazilian regulation; and (ii) the definition of “modules” and the area occupied by each object in the physical space of the site.

Note: It will be called “module” the physical space occupied by each object belonging to the installation, which was considered in the worksheet.

For the calculation of this installation, the following objects were considered, or areas belonging to the physical space:
- Shower
- Circulation Shower
- Lavatory
- Toilet seat
- Urinal (for men only)
- Entrance, walls, access and other circulations
- Individual lockers
- Seat
- Dressing room circulation

3.3.1.1 Definition of each Object Quantities

<table>
<thead>
<tr>
<th>Quantities – Bathroom and dressing room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Shower</td>
</tr>
<tr>
<td>Circulation Shower</td>
</tr>
<tr>
<td>Lavatory</td>
</tr>
<tr>
<td>Toilet seat</td>
</tr>
<tr>
<td>Urinal</td>
</tr>
<tr>
<td>Entrance, walls, access and other</td>
</tr>
<tr>
<td>Dressing room</td>
</tr>
<tr>
<td>Individual lockers</td>
</tr>
<tr>
<td>Seat</td>
</tr>
<tr>
<td>Dressing room circulation</td>
</tr>
</tbody>
</table>
### 3.3.1.2 Definition of modules and Areas

- **Shower Module**
  Unit area = 0.90m x 0.90m; Unit area = 0.81 m²

- **Shower Circulation Module**
  Unit area = 0.90m x 0.80m; Unit area = 0.72 m²

- **Lavatory Module**
  Unit area = 0.60m x 0.70m; Unit area = 0.42 m²

- **Toilet seat Module**
  Unit area = 0.90m x 1.12m; Unit area = 1.00 m²

- **Urinal Module**
  Unit area = 0.60m x 0.70m; Unit area = 0.42 m²

- **Individual lockers module**
  Unit area = 0.50m x 0.80m; Unit area = 0.40 m²

  Note: It was considered 2 stacking units

- **Seat module**
  Unit area = 1.00m x 0.90m; Unit area = 0.90 m²

- **Dressing room circulation module**

  Fixed circulation of 0.8m x 2.5m for every 24 workers or fraction

  Note 1: Estimated area from the hypothetical scenarios created in a practical way.

- **Entrance, Walls, Access and other circulations**

  Male bathroom = 100% of the calculated areas of sanitary facilities (shower, shower circulation, lavatory, toilet seat and urinal office).

  Female bathroom = 80% of the calculated areas of sanitary facilities (shower, shower circulation, lavatory and toilet seat)

**Note:** Estimated area from the hypothetical scenarios created, in a practical way.
3.3.2 Refectory and kitchen

3.3.2.1 Definition of each Object Quantities

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tables areas</td>
<td>Total (2 shifts)</td>
<td>According to the Brazilian Standards NR 18, item 18.4.2.11.2 (d) and NBR 12284/91, item 4.4.2 (c). According to Brazilian Standards NR 18, and NBR 12284/91 item 18.4.2.11.3, item 4.4.2 (a).</td>
</tr>
<tr>
<td>Heating meals area + circulation</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Food pantry</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Cold chamber</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Pre-Preparation Meat</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Pre-preparation Vegetables</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Pre-preparation Cereals</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Special preparations</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Cooking</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Cleaning and cupboards</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Hygiene and cooking utensils</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Administration, toilets, cleaning deposit and other</td>
<td>17%</td>
<td></td>
</tr>
</tbody>
</table>

For calculation of the percentage amounts of occupation of each sector within the kitchen it was used as a reference the suggestion of SENAC-SP (2007, p. 36).

3.3.2.2 Seating areas Modules

It was considered that the refectory could have four categories of tables, MP8, MP10, MP12 and MP14, these being respectively table for 8 people, a table for 10, table for 12 people and a table for 14 people. The table below shows the modules in each category table:

- **MP8**
  MP8 - Unit area = 3.18m x 2.43m; MP8 - Unit area = 7.73 m²

- **MP10**
  MP10 - Unit area = 3.78m x 2.43m; MP10 - Unit area = 9.19 m²

- **MP12**
  MP12 - Unit area = 4.38m x 2.43m; MP12 - Unit area = 10.64 m²

- **MP14**
  MP14 - Unit area = 4.98m x 2.43m; MP14 - Unit area = 12.10 m²

- **Auxiliary Worksheet “table area”**

To calculate the area of tables it will utilize the “table areas” tab, which was created to assist decision-making on this area will be used. Thus, in order to obtain the automated calculation of this space, it defined the following basic assumptions in this spreadsheet:
a) The tables will be distributed to fill, always, a rectangular geometry of space.

b) The spreadsheet is limited to 800 seats, or 1600 employee in two shifts.

c) It was considered that among the categories of pre-defined tables, MP8, MP10, MP12 and MP14, the space of the refectory should be composed of only one category. Therefore, the spreadsheet does not perform combination of one or more categories tables.

d) The choice of the category table that will compose the environment will be done automatically. The spreadsheet choose the combination that reaches the lower area, always obeying the foregoing assumptions.

The data of the spreadsheet “table area” feature, automatically the total area of the area tables, the width and the length of the space required, the chosen category of tables and arrangement of adopted tables, thus enabling the complete definition of the cafeteria layout.

- Heating Area of Refectory + Fixed circulation of 1.8m wide, multiplied by the refectory length, calculated in the tab “table area”.

Note 1: Estimated area from the hypothetical scenarios creation of in a practical way.

3.3.2.3 Definition of Cooking Areas

There are many jobs that give practical guidelines for the design of industrial kitchens. From the work available for research it was considered in this paper most appropriate to the kitchens of construction sites the following the design from table 3, suggested by SENAC-SP (2007, p. 35).

<table>
<thead>
<tr>
<th>number of meals</th>
<th>coefficient</th>
<th>number of meals</th>
<th>coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.9</td>
<td>700</td>
<td>0.3</td>
</tr>
<tr>
<td>150</td>
<td>0.8</td>
<td>800</td>
<td>0.3</td>
</tr>
<tr>
<td>200</td>
<td>0.7</td>
<td>900</td>
<td>0.3</td>
</tr>
<tr>
<td>250</td>
<td>0.6</td>
<td>1000</td>
<td>0.3</td>
</tr>
<tr>
<td>300</td>
<td>0.5</td>
<td>1500</td>
<td>0.28</td>
</tr>
<tr>
<td>400</td>
<td>0.4</td>
<td>2000</td>
<td>0.26</td>
</tr>
<tr>
<td>500</td>
<td>0.35</td>
<td>3000</td>
<td>0.24</td>
</tr>
<tr>
<td>600</td>
<td>0.35</td>
<td>5000</td>
<td>0.2</td>
</tr>
</tbody>
</table>

number of meals x coefficient = area (m²/person)
The SENAC-SP suggests dimensioning the total area of the kitchen (m²) from the number of meals multiplied by the above shown coefficients.

### 3.3.3 Workers’ Building

It is important to note that it was considered in the spreadsheet construction that each building unit would be composed of a maximum of 20 rooms. To construction sites which housed workers exceed 80 (4 workers per room) should have more than one workers’ building. This premise has been adopted in the scenarios created; however, it is completely possible to make adjustment in these limits if it is considered necessary.

#### 3.3.3.1 Definition of each Object Quantities

**Tabela 4 – Quantities – Workers’ building**

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedroom (until 4 workers)</td>
<td>1 for each 4 or fraction</td>
<td>According to the Brazilian Standards NR 18, items 18.4.2.10.1, 18.4.2.10.5 e 18.4.2.10.7 and NBR 12284/91, item 4.3.2.6.</td>
</tr>
<tr>
<td>Shower</td>
<td>1 for each 10 or fraction</td>
<td>According to the Brazilian Standards NR 18, item 18.4.2.4</td>
</tr>
<tr>
<td>Circulation Shower, Lavatory</td>
<td>-</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1 for each 20 or fraction</td>
<td>According to the Brazilian Standards NR 18, item 18.4.2.4</td>
</tr>
<tr>
<td>Toilet seat</td>
<td>1 for each 20 or fraction</td>
<td>According to the Brazilian Standards NR 18, item 18.4.2.4</td>
</tr>
<tr>
<td>Urinal</td>
<td>1 for each 20 or fraction</td>
<td>Male – According to the Brazilian Standards NR 18, item 18.4.2.4</td>
</tr>
<tr>
<td>Entrance, walls, access and other circulations</td>
<td>-</td>
<td>Female – Not applicable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

#### 3.3.3.2 Definition of modules and areas

- **Bedroom Module (until 4 workers)**
  
  Unit area = 3.50m x 2.70m; Unit area = 9.45 m²

  **Note 1:** There were considered included in the calculated area all the walls.

  **Note 2:** The modules are separated between male and female. However, there is no difference between the bedroom modules.

### 3.3.4 Support building

It is important to note that, such as in the workers’ building, it was considered in the support building that each bedroom unit would be composed of a maximum of 20 suites, which in this case it is 40 employees (2 workers per suite).
3.3.4.1 Definition of each Object Quantities

Table 5 – Quantities – Support building

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suite (until 2 workers)</td>
<td>1 for each 2 or fraction</td>
<td>According to the Brazilian Standards NR 18, items 18.4.2.10.1, 18.4.2.10.5 e 18.4.2.10.7 e NBR 12284/91, item 4.3.2.8.</td>
</tr>
</tbody>
</table>

3.3.4.2 Definition of modules and areas

- Suite module (until 2 workers)
  Unit area = 4.20m x 3.50m; Unit area = 14.70 m²
  Note 1: There were considered included in the area of 14.70 m² all the walls.
  Note 2: The modules are separated between male and female. However, there is no difference between the bedroom modules.

3.3.4 Laundry

3.3.4.1 Definition of each Object Quantities

Table 6 – Quantities – Laundry

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank</td>
<td>1 for each 20 or fraction</td>
<td>According to the Brazilian Standards NBR 12284/91, Item 4.6.2 (b).</td>
</tr>
<tr>
<td>Drying clothes area, walls, circulation and others</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3.3.4.2 Definition of modules and areas

- Tank module
  Unit area = 0.80m x 1.00m; Unit area = 0.80 m²

- Drying clothes area, walls, circulation and others module
  The area was considered equal to 4 times the calculated area (tanks)

3.3.5 Recreation

3.3.5.1 Definition of each Object Quantities
3.3.5.2 Definition of modules and areas

- **Games TV room**
  
  In a practical way, after the preparation of the recreation sketches, it was considered sufficient a structure to meet 1/3 of the workers, with an estimated area of 2.00 m² per person.
  
  There was not building modules for this area because they are very variable areas.
  
  It has thus been adopted that the minimum structure of this facility must meet 15 workers.

- **External Area Sports Practice**
  
  It should be informed in the area of this item in the worksheet “input data”.

3.3.6 Ambulatory

There is no standards definition about objects and dimensions that make up this space. Thus, the clinic was estimated in a practical way by drawing the sketches for scenarios, so there is no division of this facility objects.

3.3.5.1 Definition of areas

<table>
<thead>
<tr>
<th>Areas - Ambulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
</tr>
<tr>
<td>Less than 50 employees</td>
</tr>
<tr>
<td>Between 50 and 100 workers 20 m²</td>
</tr>
<tr>
<td>Between 101 and 400 workers 40 m²</td>
</tr>
<tr>
<td>Between 401 and 1,000 workers 60 m²</td>
</tr>
<tr>
<td>Between 1,001 and 1,600 workers 80 m²</td>
</tr>
</tbody>
</table>
3.4 General comments on the use of the Spreadsheet

It should be noted also some general considerations about the dimensioning spreadsheet.

- The computed area refers to the area constructed with walls up to 10cm thick, except this up the roof eaves. If necessary the consideration of roof overhangs, these should be added to the areas of the worksheet;
- The spreadsheet is limited to 1600 workers. If it is necessary to calculate the site over the number of workers to this limit, it will be necessary make sheet adjustments;
- As the number of workers considered for the calculation of each installation, it considered the following shown in Table 9.

<table>
<thead>
<tr>
<th>Considerations regarding the number of workers per each installation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Installation</strong></td>
</tr>
<tr>
<td>Bathroom and dressing room (male)</td>
</tr>
<tr>
<td>Bathroom and dressing room (female)</td>
</tr>
<tr>
<td>Refectory and kitchen</td>
</tr>
<tr>
<td>Workers' building (male)</td>
</tr>
<tr>
<td>Workers' building (female)</td>
</tr>
<tr>
<td>Support building (male)</td>
</tr>
<tr>
<td>Support building (female)</td>
</tr>
<tr>
<td>Laundry</td>
</tr>
<tr>
<td>Recreation</td>
</tr>
<tr>
<td>Ambulatory</td>
</tr>
</tbody>
</table>

4 RESULTS AND SCENARIO CREATION

In this chapter it will be presented the synthesis of the estimate results of the living areas from three hypothetical scenarios created below.

4.1 Scenario 1

The hypothetical scenario 1 was created as following in the figure 6:
From supplying the data presented in the worksheet “input data”, there are presented the results tab “summary” below.

**Figure 6 – Scenario 1**

**Figure 7 – Summary spreadsheet of scenario 1**
The spreadsheet has estimated, for scenario 1, 8 installations, with a total of built area of 260.91 m², distributed as shown above. The area of each represented installation had been evaluated and approved by building sketches and they are presented in Annex 1.

4.2 Scenario 2

The hypothetical scenario 2 was created as following in the figure 8:

Figure 8 – Scenario 2

From supplying the data presented in the worksheet “input data”, there are presented the results tab “summary” below.
The spreadsheet has estimated, for scenario 2, 8 installations, with a total of built area of 522.39 m², distributed as shown above. The area of each represented installation had been evaluated and approved by building sketches and they are presented in Annex 2.

4.3 Scenario 3

The hypothetical scenario 3 was created as following in the figure 10:
From supplying the data presented in the worksheet “input data”, there are presented the results tab “summary” below.

**Figure 11 – Summary spreadsheet of scenario 3**
The spreadsheet has estimated, for scenario 3, 14 installations, with a total of built area of 2960.37 m², distributed as shown above. The area of each represented installation had been evaluated and approved by building sketches and they are presented in Annex 3.

4 CONCLUSION

The spreadsheet created for the dimensioning of the living area in a construction site was divided into three tabs, which were “input data”, “dimensioning” and “summary”. The tab “input data” is the sheet that the engineer must enter the relevant information to the work that he wants to calculate. The tabs “dimensioning” and “summary” provide automatically data, and it is not necessary any operation.

They were structured 10 facilities in dimensioning spreadsheet, containing the following element described below:

- Bathroom and dressing room (male)
- Bathroom and dressing room (female)
- Refectory and kitchen
- Workers’ building (male)
- Workers’ building (female)
- Support building (male)
- Support building (female)
- Laundry
- Recreation
- Ambulatory

The construction of spreadsheet started by determining the quantities of each object belonging to the living area of the premises carried out in accordance with auditing standards in force.

After defining the quantities, started the development of areas of modules for each living area of the element, always respecting the Brazilian standards. Information concerning the entry areas, walls and other elements, which could not defined by areas modules, they were defined in a practical way with the creation of three scenarios of hypothetical works.

The determination of the areas was made by simple formula sum, thus representing the total constructed for each installation.

Of the three scenarios created, it was considered, at the peak of the work, the scenario 1 with 63 workers, scenario 2 with 137 workers and scenario 3 with 620 workers.

In terms of results, the scenario 1 presented the design of 8 installations, with a total built area of 60.91
m². Scenario 2 resulted in estimated 8 installations, with a total built area of 522.39 m². Finally, Scenario 3 presented 14 installations and constructed area of 2960.37 m².

All areas that represent each installation created the scenarios were evaluated and considered feasible construction, also for economical design and meeting the minimum requirements by the Brazilian regulation. The sketches used for the achievement of each testing facility are presented in Annexes 1, 2 and 3 of this paper.

Therefore, this paper is finished bringing a very viable tool to be used in the design of the construction site, assisting in decision-making and promoting the speed of this step in the preparation of reference budgets for engineering works.

5 REFERENCES


ANNEX 1 – SKETCHING IN AUTOCAD: SCENARIO 1

- Bathroom and dressing room (male) 24 workers, Area = 26.08m²

- Bathroom and dressing room (female): 7 workers, Area = 9.83m²
• Refectory & kitchen: 32 workers, Area = 42.36m²
- Workers’ building (Male): 32 workers, Area = 95.24m²
- Support building (Male): 4 workers, Area = 29.40m²

- Laundry: 32 workers, Area = 8.00m²
- Recreation: 32 workers, Area = 30.00m²

- Ambulatory: 63 workers, Area = 20,00m²
ANNEX 2 – SKETCHING IN AUTOCAD: SCENARIO 2

- Bathroom and dressing room (Male): 76 workers, Area = 70.56m²
- Bathroom dressing room (Female): 17 workers, Area = 15.48 m²
- Refectory and kitchen: 137 workers, Area = 210.81m²
- Workers’ building (Male): 40 workers, Area = 114.14m²
- Support building (Male): 4 workers, Area = 29.40m²

- Laundry: 44 workers, Area = 12.00m²
- Recreation: 44 workers, Area = 30.00m²
- Ambulatory: 137 workers, Area = 40.00m²
ANNEX 3 – SKETCHING IN AUTOCAD: SCENARIO 3

- Bathroom and dressing room (Male): 236 workers, Area = 211.10 m²
- Bathroom and dressing room (female): 36 workers, Area = 30.96m²
- Refectory e kitchen: 620 workers, Area = 561.22m²
- Workers’ building (Male): 304 workers

Building: 80 workers, Area = 228.26m² (3x)

Building: 64 workers, Area = 70.11m² (1x)
- Workers' building (Female): 24 workers

Building: 24 workers, Area = 70.11m² (1x)
- Support building (Male): 20 workers

Building: 20 workers, Area =147.00m² (1x)
- Support building (Female): 8 workers

Building: 8 workers, Area $=58.80\text{m}^2$ (1x)
- Laundry: 348 workers, Area = 72.00m²
Recreation: 348 workers

Games and TV room, 348 workers, Area =232.00m² (1x)
- External Area Sports Practice, 348 workers, Area = 645.00m² (1x)
- Ambulatory: 620 workers, Area = 60.00m²
ABSTRACT

Project management decisions are based on cost, schedule, scope considerations and constraints.

It is usual to set triple constraint determining cost, schedule and scope targets that project shall meet. But setting separate targets makes project management complex and not reliable. Simple questions - like if it is profitable to pay certain additional money for project acceleration – do not have certain answers, decisions are subjective and often lead to project losses.

Project managers usually do not have an authority to change project scope. They manage project resources that have direct impact on both project cost and schedule.

When project cost and schedule baseline and cost of time are set, project management decisions become easy to justify by the benefits they provide.

However, such approach requires correct modelling of project expenses. Most norms and estimates refer to the units of volume of certain activity types and resource productivity is measured as activity volume per work hour. Therefore, only if activity volumes for calculating both project schedule and project budget cost are used, it is possible to achieve true cost/schedule integration.

Project cost shall be assigned following ways:

- Activity costs may be defined as fixed, cost per volume unit, and cost per work hour.
- Renewable resource cost may be defined as the cost per hour.
- Consumable resource cost may be defined as the cost per unit.
- Assignment cost also may be fixed, or defined as the cost per work unit and hour.
- Indirect costs usually depend on project duration and are assigned on Level of Effort or Hammock activities.
- Cost of time also shall become a part of the project model, so project cost raises with the finish delay and drops with the schedule acceleration.

Project management tool shall be able to calculate project schedule taking into account volumes of work to be done, resource productivity and availability, material supply and funding constraints. Only then
cost/schedule integration may become full and reliable.

We will describe cost/schedule integration on simple examples created with Spider Project software, which gives project managers the ability to set schedule/cost targets and effectively use them to promote management decisions regarding the needs of the project for keeping its original goals.

**Purpose of this paper (mandatory)**

The purpose of this paper is to describe methods and tools of cost and schedule integration that are successfully used in Russia and Eastern Europe but almost unknown in other parts of the world. Their application can substantially improve project performance.

**Design/methodology/approach (mandatory)**

Quantity management is a keystone of cost-schedule integration. Integrated project model shall include all parameters and constraints that determine project cost and duration.

Multiple project success criteria like cost, duration, scope make the management complicated and not reliable. It is necessary to set single project success criterion that integrates scope, cost and schedule goals.

Reliable project management shall take into account uncertainty and risks. Creating and managing contingency reserves increase project success reliability.

**Findings and value (mandatory)**

Traditional methods of project planning are based on techniques developed in the middle of the last century like Critical Path Method and PERT. These techniques are based on activity duration estimates, ignore project resource, supply and funding constraints, and are not designed for cost-schedule integration. The application of the suggested methods and tools presented in this paper can increase project success reliability, promoting time and money savings.

**Originality/value of paper (mandatory)**

Methods and tools described in this paper are based on the common sense and are used in many projects in Russia and Eastern Europe. However, common approaches supported and promoted by major International project management associations are still based on old techniques developed in the middle of the last century. This paper presents methods of project planning and project management that integrate estimating and scheduling to promote better results in cost and time to any given project.

**Conclusions**

Cost and schedule integration requires management of quantities, taking into account all project constraints, and setting integrated project success criteria. Risk simulation and creating cost and time con-
tingency reserves improves the reliability of achieving project targets.

Application of suggested methodology can significantly improve project management culture and increase the number of successful project implementations.

Keywords (no more than 5): project management, scheduling, budgeting, integration, optimization, risk management

1. PROJECT DATA

Cost-schedule integration starts with creating right project model that includes all data that people use for project planning and decision-making.

1.1. Cost Data

It is not sufficient to manage just cost. Project cost consists of cost components that shall be entered and analysed separately.

- Simple example:
  - Internal expenses consist of labour cost, cost of materials, cost of machines, indirect costs, etc. Besides, activities may have contract costs. So it is necessary to define cost components that will be used for project budgeting and cost performance analysis.
  - Cost components may represent different currencies and so have different unit costs.
  - Planning and analysis may be required for groups of cost components that are called Cost Centres. Cost Centres may represent parallel project budgets (example: Internal expenses, Contract costs).
  - In projects with long duration, cost discounting may be used and discounting rate may be assigned to each component separately.

1.2. Activities Control

When people plan project activities they estimate activity volumes of work to be done. Only for some activities such as getting approval, receiving permission, curing concrete the volume of work is hard to estimate or it does not matter. For these activities people use duration estimates as initial activity information.

So most activities belong to the following two main types:

- **Duration Type Activities** are those which duration is their initial information and does not depend on the volume of work to be done.

- **Volume Type Activities** are characterized by the volume of work to be done. Activity volume is usually measured in the physical units (cubic meters, tons, meters, units, etc.) though other measures like man-hours also can be used. Duration of volume type activity depends on productivity of assigned resources.
Besides, an activity may be of Level of Effort or Hammock type when its duration is determined by external events, so an activity lasts from one event to another.

One more special activity type is Milestone: an activity with zero duration that usually reflects some event in the project schedule.

Activity cost and material requirements may be defined as fixed amount that does not depend on activity volume or duration, as an amount per unit of volume, or as amount per unit of duration.

Costs are assigned directly to activities if they do not depend on assigned resources. It could be contract cost components as an example.

Activity calendar defines time periods when an activity may be executed. Some activities may be executed only at day time, others only on Summer or on Winter. Activity calendars shall be taken into account when the project is scheduled.

Activities are of the same Type if they share the same properties like cost and material requirements per volume unit, resource requirements and productivity. Activities of the same type may have different volumes and may be done at different places, at different time and even in different projects.

1.3. Resource Properties

Project resources may be divided into two main classes:

- Renewable resources that may be used again after they finished the job where they were assigned,
- Consumable resources that are spent on activities where they were assigned and so could not be used anymore.

Renewable resource (labour, machines) properties include available quantities at different time periods, resource calendar (time periods when resource may work), hour cost and hour consumption of project materials (a machine may use certain amount of fuel or electricity per work hour).

Consumable resource properties include unit of measure and unit cost that may be different at different time periods. Consumable resources do not have special calendars.

Resources (both renewable and consumable) may be produced on project activities (examples: mobilization for renewable resources and supply for materials), they also may be spent or removed from the project team on other activities (usually milestones).

1.4. Resource Assignment Properties

Activity duration depends on the capabilities of assigned resources.

Renewable resources may be assigned different ways:
• They may work as a team and do the job together – in this case if some resource belonging to the assigned team is not available the whole team will not work,
• Assignments may be independent – resources may do their work independently of each other and at different time.

Independent assignments are useful for modelling work in several shifts.

Assignments may be partial when assigned resource works on the activity only certain percent of the work time. In this case the rest of its work time assigned resource may use working on other activities.

Assignments may be variable when activity resource requirements are defined as a range, specifying minimal and maximal quantity and workload. An example: brick works may start when two masons become available and if more masons will become available (up to maximal number) before the work is finished they will join and accelerate the work. The same with workload: the job may start if assigned resource can devote at least 40% of work time to this activity but if nothing else is required assigned resource will work on the activity 100% of work time.

Resource assignment productivity determines the duration of volume type activities.

Productivity may be set to individual assignments or to assigned crews. It is usually measured as volume of work done in time unit. Activity duration is calculated as Volume of work divided by total productivity of assigned resources for team full time assignments but it is more complicated for independent assignments. With independent assignments, activity duration is calculated in the process of scheduling when it becomes known what share of activity volume will be done by each resource.

Another assignment property is resource workload that is 100% for full time assignments and may be less for part time assignments. For part time team assignments, team productivity may be calculated as the sum of assigned resource productivity multiplied by their workloads.

Resource assignment properties may also include assignment cost and assignment material consumption that may be set as fixed or as an amount per volume or duration unit.

Another way of resource assignment is assigning not concrete resources but resource skills. Resources have the same skill if they can execute an activity of certain type though maybe with different productivity and cost. If resource skills are known and were assigned the software (if has required functionality) or people select what resource will do what basing on resource skills, availability, productivity, cost and user defined priorities. Project resource constrained scheduling with automatic resource assignments basing on resource skills and availability is called skill scheduling.

1.5. Activity dependencies

Project model shall include activity logical dependencies that reflect real life constraints on the order of activity execution. Standard Finish-Start (FS), Start-Start (SS), Finish-Finish (FF) and Start-Finish (SF) links connect activity start and finish points with No Earlier Than dependencies.
SS and FF dependencies usually mean that two activities may be done in parallel but with some lag. Usually it means that the next activity may start only after certain amount of work on preceding activity has been executed, defining certain minimal “distance” between crews on preceding and succeeding activities. This distance is usually measured in volume units and the lag defined this way is called volume lag.

Time lag defines time interval between activity start or finish events and is used for duration type activities. Time lag may have its own calendar different from the calendars of linked activities.

It is not sufficient to connect activity start points. It is usual when the distance between working crews shall be kept until preceding activity finish, so SS link with Lag shall be accompanied by FF link with Lag.

It could be also useful to add point to point dependency or double lag dependency when certain point of preceding activity is inked with some point of succeeding activity. These points may be defined as Starts Plus Volume Lags.

1.6. Conditional Networks

In the real life the way project is executed depends on its status. When major milestones are late people apply corrective actions, use additional resources or more advanced technology at the rest of the project. It is useful to develop these actions before the need in them will become urgent and create the model where they will be applied automatically if needed.

1.7. Norms and Reference-books

Project estimating is based on application of different kinds of norms.

Norms may include resource productivity on different types of activities, material consumption per volume unit of different activity types, unit costs, crews required for doing different activity types, etc. Most norms are applied to work volume units (cubic meters, square meters, tons, pieces, etc.).

Databases of the corporate norms that we call Reference-books are used in all corporate projects. If the set of the corporate Reference-books is properly created and organized it is sufficient to enter activity type and volume and get everything else from the Reference-books automatically including the crew that shall do the work, its productivity, activity duration, cost and material consumption. Project managers can make some adjustments but all basic information that is used for cost and schedule estimation is readily available.

1.8. Conclusions about project data

Main types and properties of project activities, resources, resource assignments and activity dependencies that people use when planning their projects were listed. Project management software shall be able to model this data for creating feasible project model that people will accept and use. Not everything is used in every project but if the software does not model something that Corporate project management system shall include and use corporate norms.is needed then the results it produces have very limited
value.

Unfortunately, most popular project management packages do not model:

- cost components and cost centres
- activity volumes,
- consumption of materials by renewable resources,
- resource assignment productivity,
- unit cost and material requirements,
- independent and variable resource assignments,
- volume lags,
- point to point dependencies,
- conditional networks.

Project model shall include everything that is needed for proper management and cost-schedule integration including all project constraints like resource and funding restrictions.

2. PROJECT SCHEDULING AND BUDGETING

Project schedule shall be calculated taking into account all existing constraints including available renewable resource quantities, the schedule of consumable resources supplies, funding restrictions.

As the result of the project scheduling following information becomes available:

- Time of all activities starts and finishes,
- Workload of project resources at any time moment
- Material flows
- Project budget (expenses)
- Contract budget (payments)

Investors may include in the project model time phased forecast of future profits. In this case they will be able to calculate payback period, NPV, IRR and other parameters useful for investment analysis.

3. PROJECT SUCCESS CRITERIA

The usual practice of setting several success criteria for the project team like achieving all goals on time and on budget makes management decisions complicated and not reliable. It is not easy to decide even if it makes sense to spend certain amount of money for one-week project acceleration.

But it is possible to calculate the cost of project delay and acceleration for project Owners and Contractors.

For Owners project finish delay means that project product will start to generate profit later. Basing on
lost profits it is possible to estimate the losses of each day of project delay.

For Contractors each day of the project execution means expenses that are needed for payments for project resources, safety, management and other indirect costs. Besides there are penalties that should be paid if contract dates were missed.

So both parties may estimate their costs of each day of delay and acceleration.

This information may be used for comparison of different versions of the project plan and selecting the best one for approval.

When project cost and schedule baselines were approved it is reasonable to set one integrated project success criterion that is project cost plus costs of each day of acceleration (negative) and each day of finish delay (positive). This criterion motivates project team to perform project faster and for lower cost but permits to justify additional expenses if they were done to accelerate project execution: if total cost that includes acceleration and delay costs becomes lower then it makes sense to pay. Our practice showed much better performance of project teams that had this success criterion in their projects.

4. RISK SIMULATION

Project plans become much more reliable if planning takes into account risks and uncertainty.

For project risk simulation it is necessary to simulate uncertainty by entering ranges of project parameters (setting their optimistic, most likely and pessimistic values). Risk events are simulated by special zero duration activities called triggers that have certain probabilities to happen. If trigger happens it may generate several branches of activities in the project schedule, each branch with its own probability. (probabilistic branches). Project management software that includes risk simulation shall be able to model GERT Networks that include conditional and probabilistic branches.

Any method of risk simulation (Three Scenarios, Monte Carlo, etc.) provides probability curves of project parameters that are used for setting reliable target dates and costs. One of the simulated parameters is project success criterion. It is necessary to set reliable and achievable goals for proper motivation of project teams.

Risk simulation shall be done using the same model that will be used for project management. It shall include all project constraints and use the same algorithms for resource allocation that will be used in day by day management. If these conditions are not met risk simulation will produce wrong results because what was simulated is not the same as what will happen in the real life. Risk simulation with the use of external tools shall be used only for projects with unlimited resources.

Project target dates selected by risk simulation do not belong to any special schedule. The schedule that is used for management finishes earlier and the difference between target and schedule finish dates is called project time buffer. Time buffer is time contingency reserve created for absorption of time delays caused by expected risk events and uncertainty.
The same with project budget. Target cost and the total cost of the management schedule are not the same. Target cost includes cost contingency reserve that is called project cost buffer.

Buffers may be created for all project parameters that are planned and of course for project success criterion.

It is reasonable to use optimistic scenario as project management schedule to avoid unnecessary loss of time and money caused by Parkinson Law.

5. PROJECT PERFORMANCE ANALYSIS

When targets and management schedule are set project is managed usual way: resources are allocated basing on management schedule, actual data are collected and entered in the model, remaining works are regularly rescheduled. With each project update risk simulation is repeated and probability of meeting project targets recalculated.

If probability of meeting project targets is increasing it means that project buffers are consumed slower than expected and project performance is successful. Negative trend of meeting project target probability shows potential problem and requires corrective actions. Project management team makes management decisions looking at current status and trends of project success criterion. Decisions to accelerate project execution spending more money or save money using cheaper or less resources are justified if increase the probability to meet project success criterion target.

5.1. EXAMPLES

Application of methods described above will be illustrated using small sample construction project “1km Road Construction” shown in Figure 1.
As shown at Figure 1 project activities have volumes of work measured in physical units (m, m², m³, pieces), each activity has internal cost (expenses) and contract cost. Contract costs are assigned as fixed but expenses are calculated basing on assigned resource costs. Project schedule in Figure 1 is optimistic.

5.2. Project Cost Data

Cost components of this sample project Include Material Cost, Machine Cost, Labor Cost, Indirect Cost, External services, Contract Cost, Penalties, Cost of Delay.

Indirect cost in this project is calculated automatically as 118% of the cost of materials, machines and labor.

Contract cost is set as negative because contract money come to this project.

Penalties are set as 3000 units for each work hour of project delay.

Cost of each hour of delay for the project team is set as 2000 units per hour.

Cost Centers include Expenses that include material costs, machine costs, labor costs, indirect costs and cost of external services, Contract Cost that includes contract costs and penalties, Profit that includes Expenses and Contract Cost and Criterion that includes Expenses, cost of delays and penalties.
5.3. Project Resource Data

Project uses following machines: two graders, two different bulldozers, two different excavators, two scrapers, nine trucks, two vibro rollers, bitumen distributor, asphalt paver, two road rollers, special car for marking the road. Each car consumes fuel and an amount of fuel consumed per hour was set for each machine. So the software will calculate expected fuel consumption basing on planned and actual machine work hours.

Human resources include nine drivers, nine machinists and eight workers. Cost of management resources was included in indirect cost.

External services are used on Sand and Crush Stone Transportation activity that is assigned to external supplier.

Each renewable resource has the cost of work hour (set as labor or machine cost component) except External Supplier who is paid for the amount of work done.

Sample project uses following materials: Fuel, Bitumen, Crush Stone, Sand, Asphalt, Paint, Steel, Road Signs. For each material its unit cost was set in Material Cost component.

Each activity is executed by certain resource crew that includes resources working together.

For example Ditch Crew consists of three trucks with drivers, one scraper, one grader and one excavator with machinists, and two workers. This project uses two excavators with different capacities and costs. So the crew includes skill Excavator and the software selects what excavator to assign basing on resource availability, productivity and cost.

5.4. Project schedule

Activity dependencies and project schedule are shown in Figure 1.

The schedule is resource leveled. With unlimited resources it could be two days shorter.

During scheduling the software selected what excavator and what bulldozer to use on each activity were skills Excavator and Bulldozer were assigned.

Project Expenses and Contract Costs were calculated.

Since the schedule is optimistic the cost of acceleration was not defined and the cost of delay that is used in project team success criterion will start from the day following the day of optimistic schedule finish.

For automatic calculation of the cost of delay and contract penalties two milestones were added to the schedule.

Early Finish milestone has certain start date 05-09-2016. This is optimistic project finish and cost of de-
lay is assigned to an activity Cost of Delay that lasts from Early Finish milestone start to project Finish (hammock activity).

The date of second milestone Target Finish is 08-09-2016. In accordance with the contract this project shall be finished no later this date and starting from 18:00 of 08-09-2016 contract penalties will be applied.

Penalties were assigned to the activity Penalties that starts on Target Finish and finishes with the project finish. So this activity is also of hammock type and has zero duration in the optimistic project version. But in pessimistic scenario losts could become substantial as shown in Figure 2.

![Figure 2. Cost of Time](image)

5.5. Risk simulation

Risk simulation was applied and targets were set basing on analysis of the following probability distributions.
5.5.1. Project Duration

Figure 3. Project Duration Probability Distribution

5.5.2. Project Expenses

Figure 4. Project Expenses Probability Distribution
5.5.3. Project Success Criterion
5.5.1 Reference-books

Reference-books store corporate norms that shall be used for project planners.

An example of the Reference-book used in our sample project with material requirements per volume unit of typical activities is shown below.

![Figure 7. An example of material requirements per activity type volume unit reference-book](image)

Reference-books may be created for any project parameters. They can integrate estimating and scheduling that is an important part of cost-schedule integration.

5.5.2 Scatter Diagrams

Scatter Diagrams show probability of simultaneous achievement of several targets.

It is natural that probability of achieving several targets is lower than achieving each of them.

For example, finishing project in less than 34 days and under 3000 value of project success criterion has 69% probability though separately their probabilities are 80% and 73.2%.

Correlation between these parameters is shown below.
Figure 8. Scatter Diagram for Criterion – Duration

Figure 9. Criticality Indexes of sample project schedule activities
5.5.3. Project Performance Analysis

Figure 10 shows an example of project performance analysis.

Diagram under project Gantt Chart shows project success probability trends for success criterion and duration.

Trends show that project performance was successful though there were problems at its third week. It is clear that project will finish on time (probability is close to 100%) and project success criterion will be met (probability is close to 90% and rising) though cost of time (23126.11) is added to the project budget.

6. CONCLUSIONS

Cost and Schedule integration is based on management of volumes of work and application of the corporate norms. Most norms are applied to volume units of typical activities in physical units and the software that integrates cost and schedule shall be able to use them.

Project model shall reflect real life work and constraints. Project constraints may include not only renewable resource constraints but also material supply and funding restrictions. The scheduling software shall be able to take into account all project constraints to be able to create feasible project schedules.

Cost and schedule integration requires setting right project success criterion for project management team. The easiest way is to define cost and schedule baselines and add the cost of delay or acceleration to the approved project cost. Delay and acceleration costs depend on the project nature. Integrated project success criterion helps to make and to justify project management decisions.
Reliable management requires application of risk management, creating contingency reserves for project cost and duration. Risk simulation permits to calculate required reserves and to set reliable project targets. Project performance analysis includes calculation and analysis of probabilities to meet set targets (success probabilities). Success probability trends show the problems early. Even if project status is satisfactory but trends are negative corrective actions shall be considered. The main object for success probability trend analysis is integrated project success criterion.

Methods and approaches described in this paper are successfully used in Russia for many years but are not widely known abroad. It is time to move forward from the last century techniques developed when computers were rare and had very limited capabilities.

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When Overbilling is Legal

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ABSTRACT

Purpose

The purpose of this article is to demonstrate the decisive influence of legislation in the way of how the execution of Brazilian public work is contracted. As it stands, the risk for hired company is minimized and their profit is maximized. In addition, it embeds a fictitious cost in the final price - the supercost - which gives rise to a type of sub-referential, legal, overbilling, i.e. it is overbilling (overcharging) because it has the same fictitious nature of a fraud, but its origins are in legislation, not in work execution. As such, it is untraceable by auditing and control departments.

Methodology

A survey was made in the Brazilian law chronology in order to identify main historical effects in public work contracting schemes. Budgeting basics were analyzed to understand how induced excess in the cost propagates to the price. An analysis of the whole public work contracting system was made to understand how and why overbilling occurs, and why it cannot be fought. Many contributions of the Brazilian Federal Police on this theme were presented. Relationship between law, supercost, overbilling and public work budget is discussed.

Practical implications

It points to the need of changing the Brazilian legislation.

Value

For the first time, the overbilling problem is analyzed systematically.
Conclusions

The Overbilling of the Brazilian public work is systemic. It does not represent the system corruption, but its very purpose. Its origin can be traced back to the Brazilian legislation itself as a supercost (a fictitious cost). The problem can only be eliminated if the legislation is modified.

Keywords: supercost, overbilling, budget, public works, engineering.

1. INTRODUCTION

Construction industry is one of the most important sectors of the Brazilian economy, since it covers approximately 9% of all employed population, 8% of GDP and investments of R$ 120 billion according to data from CBIC (Brazilian Chamber of Construction Industry).

The most significant segment of this sector is the public work, mainly due to its size and typology. However, public work engineering struggles with the overbilling problem, which has reached critical levels as to a point of threatening the sector survival, Brazilian civil engineering, and the country's economy as a whole.

This article proposes an analysis of overbilling problem under a new systemic light: trying to reveal its origin, how it spreads and why it cannot be eliminated in the current form.

2. BUDGETING REVISITED

The relationship between budget variables can be summarized by two basic equations (adapted from Portuguese), Figure 1 (MÁRIO LOPES, 2014b). The first one relates Selling Price (PV) to Total Cost (C) and a percentage (i%) combining Tax Rate (IMP%) and Margin of Profitability required by the performing company (LO%). By Tax Rate (IMP%) one means the ratio of Taxes (IMP) and Selling Price (PV). By Margin of Profitability (LO%) one means the ratio of Operational Profit (LO) and Selling Price (PV).

The second equation relates Selling Price (PV) to Direct Cost (CD) through the BDI (Bonus and Indirect Expenses). The BDI is obtained by the ratio of Indirect Cost (CI), Accessory Cost (CA), Taxes (IMP) and the Operational Profit (LO) over Direct Cost (CD).

The use of both equations allows the relation of Selling Price (PV), Total Cost (C) and Profitability Margin (LO%), provided that one knows about the intrinsic parameters of budgetary reality of the performing company that are relevant to the work being performed, such as Indirect Cost (CI), Accessory Cost (CA) and BDI.
In Brazil, there are basically two hiring schemes for engineering services: “work by administration” and “work on contract”. Whatever the chosen hiring scheme is, it will always be necessary to budget the work and, in both cases, budgeting begins with a cost estimate. Obviously, between budgeting and execution, the cost of the work is subject to change. What differentiates one scheme from another is how this change in cost is handled. In “work by administration”, one fixes profitability margin and monitors up the price - which increases along with the increase of the cost. In “work on contract”, one fixes the price and monitors up profitability margin - which decreases along with the increase of the cost, Figure 2.

Since a budget is never exact, there will always be an inherent risk to the cost estimate of the work. This risk appears in both schemes, and serves as a parameter for choosing between one and another, that is, as the risk depends on the degree of budgetary accuracy, the “work on contract” scheme is best suited to situations where there is a reasonable accuracy in cost estimate. On the other hand, if one does not have enough information for a good cost estimate, the “work by administration” scheme is recommended. Figure 3 (MÁRIO LOPES, 2014b) illustrates the risk analysis when the Government is the contractor.
Engineering goods and services are charged by issuing a document called Invoice, which contains the price of those goods or services. When the charged price is excessive, it is said that there was overpricing, and its charging is called overbilling. Overbilling should be measured in relation to what was really executed (basic concept of overbilling), but traditionally this has not been the case in Brazil.

3. “UNDER CONSENT OF THE” ... LAW

In a period of 7 years, between 1992 and 1998, a set of only four laws practically defined the format of the Brazilian system for contracting public work. They were: Law 8429 (06.02.1992), Law 8666 (06.21.1993), Law 8883 (06.08.1994) and Law 9648 (05.27.1998). A second set of laws (the known LDOs), acting in the period from 2003 to 2013, improved the proposed model and was consolidated by Decree: LDO 2003 (07.25.2002) until the LDO 2013 (08.17.2012), the last one being replaced by Decree 7983 (04.08.2013). These changes are listed briefly in Table 1 and are commented below:
Table 1. Chronology of legislative changes.

<table>
<thead>
<tr>
<th>Description</th>
<th>Law / Decree</th>
<th>Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of contract scheme.</td>
<td>8883, 9548</td>
<td>60, VIII, C; 10, II, C; 10, § 40, XII</td>
</tr>
<tr>
<td></td>
<td>Dec 7983</td>
<td>20, VII</td>
</tr>
<tr>
<td>Adoption of overestimated referential cost.</td>
<td>LDO 2003-2013</td>
<td>102, Caput</td>
</tr>
<tr>
<td>Possibility of price addiction.</td>
<td>8666</td>
<td>65, § 1º</td>
</tr>
<tr>
<td>Redundant, referential or attenuated control.</td>
<td>8429, 8666</td>
<td>10, 96, I e V</td>
</tr>
<tr>
<td></td>
<td>LDO 2003-2013</td>
<td>102, § 5º, IV; 125, § 6º, VI</td>
</tr>
</tbody>
</table>

The first significant change included elimination of the “work by administration” scheme, definition of payment at the conclusion of contract and the possibility of maximum price fixing. Thus, directing public work almost exclusively for the “work on contract” scheme.

In the “work on contract” scheme, it is necessary to establish the price beforehand. As the Brazilian Government does not perform the work (with rare exceptions, such as work in the Brazilian Army facility), it wouldn’t be able to budget them. A solution to this was the second change: the adoption of a reference system (SINAPI or SICRO) to obtain the costs.

From this point on, the Brazilian contracting system of public work was shifted from the real world to a world of reference, Figure 4, that is, it was created a kind of market reserve (or parallel market) to the public work executing companies, where the “market price” is presented as the price charged by these companies within the private sector, which is not true. Since then, overbilling has been considered as an excessive charge in relation to the reference price (or market price) and not relative to the real price anymore. This excess in relation to a reference system has become the traditional concept of overbilling.

Figure 4. Parallel market of public works.

An important detail: in the law, it was decided to adopt unit costs (i.e. retail costs) as reference and, therefore, overestimated costs. There is nothing against the adoption of a reference, provided it is subject to regular and iterative reassessment in order to converge it to the real situation. In Brazil, the adoption of overestimated cost in the “work on contract” scheme, without any kind of reassessment, allows
the maximization of profit by the reducing of costs, not by the increasing of prices, since these, in theory, are already limited. So, for public work, Figure 3 would assume the Figure 5 format.

**Figure 5.** Figure 3 for public works.

It is noteworthy that these changes are not able to solve the Brazilian Government’s problem of budgeting works, since it does not know the BDI of the performing company. Then one adopts a mean BDI, alienated from the company’s reality and from the work yet to be performed. Under these conditions, Figure 1, for public work, is equivalent to Figure 6.

**Figure 6.** Figure 1 for public works.
The next modification was the possibility of price addition. But price addition is a spurious expedient to the “work on contract” scheme, since it is inherent of the “work by administration” scheme and should not be used to treat (in the “work on contract” scheme) what would correspond to a change in object, allowing new hiring. The “work on contract” scheme is essentially a risk contract. Adding to this the possibility of price addition (without corresponding possibility of disallowance in the same law), the risk is no longer isonomic and directs itself (now twice) to the Government, i.e., the cost can be reduced and the price may increase.

It also created the possibility of performing spreadsheet games - one of which allows creating price additions artificially. Then, for public work, Figure 2d would look like Figure 7. The last change was the adoption of a redundant, referential, attenuated control. It is redundant because it tries to control the price which, in theory, is already limited by the “work on contract” scheme. It is referential because it uses the price obtained in a reference market (the market price) as a reference, and not in the real market or even the real price of the work. It is attenuated because it uses control criteria defined in relative (or subjective) terms, such as “arbitrary”, “unfair” and “duly justified”.

Therefore, in Brazil, the hiring of public work is limited to the “work on contract” scheme with overestimated cost (retail), possibility of price addition and referential, redundant, attenuated control. The Government hires the work without knowing, really, what are: cost and price of the work, BDI and profitability of hired company.

*Figure 7.* “Work on contract” scheme for public works.

In the case of public work, performed with public funds, derived from taxes paid by tax payers, where should apply the principle of publicity and the supremacy of collective rights over individual rights, a set of laws aiming (in theory) the absolute control of public works budget but (in practice) allowing no control at all, seems at least paradoxical.
4. CONTRIBUTIONS OF BRAZILIAN FEDERAL POLICE WORK

Some auditing procedures performed by the Brazilian Federal Police led to revealing conclusions about the overbilling theme. These conclusions were published in an attempt to contribute to the discussion of the topic.

4.1 What is Overbilling?

The Modern concept of overbilling extends the traditional concept. It was first proposed by ALAN LOPES during discussions of the draft bill PL 6735/2006, in the Brazilian House of Representatives in 2006. This concept was expanded by OLIVEIRA JR. et al (2008). It was later published in a book by ALAN LOPES (2011). In general, the overbilling modern concept, according to the expanded definition of OLIVEIRA JR. et al (2011), is characterized as:

- Measuring more quantities than what actually was executed / provided;
- Deficiency in the execution of engineering work and service, resulting in decreased quality, lifespan or safety;
- Payment of work, goods and services using prices clearly higher than the central tendency (median or mean) practiced by the market, or incompatible with the objectives set by the relevant official bodies, as well as the practice of unit prices above the market central tendency (median or mean);
- Breaking the initial economic and financial balance of the contract in the Government disfavor by changing quantitative (sheet set) and / or prices (changes in financial terms) during the execution of the work);
- Changing financial deals generating anticipated contractual receipts, distortion of the physical and financial schedule, unwarranted extension of the contract term or irregular readjustments.

MÁRIO LOPES (2014a and 2014b) proposed a Necessary Concept of overbilling that is essentially a return to the basic concept of overbilling by granting the public nature of information concerning public work: “Overbilling is to issue an invoice with PRICE above the REAL PRICE of service.”

It also introduced the concept of SUPERCOST: a fictional, hidden cost in the price of public works, corresponding to the difference between the reproduction (or reference) and real costs. Supercost has its origins in the Law and gives rise to SUPERPRICE that, when charged, corresponds to an under-referential, legal, overbilling. Finally, he cited four types of overbilling, Figure 8.
4.2 How to Quantify Overbilling?

Both OLIVEIRA JR et al (2008) and ALAN LOPES (2011) presented a complete methodology for quantification of overbilling.

4.3 How does Overbilling occur?

LIMA (2009) demonstrated, through the compilation and statistical analysis of bids, the contracted prices in a competitive environment, where the presence of eight or more qualified bidders inhibits the conclusion of agreements, are around 35% lower than those presented in the bidding invitation, Figure 9.
SILVA FILHO et al (2010) demonstrated the existence of a phenomena that allow the occurrence of over-billing below reference price, Figure 10 (originally in Portuguese). In particular, the quotation, scale and bargaining effects were treated.

Figure 10. Phenomena that allow the occurrence of overbilling below the reference price (in Portuguese).
**Scale effect** corresponds to the efficiency gain by repetition of service, either by increasing productivity, either by reducing losses.

**Quotation effect** corresponds to a partial market research and purchase at the lowest price, rather than an entire market research and purchase at the reference median price. The authors used 40 standard projects available in the SINAPI catalog and 4 real audited works by Federal Police experts. The smallest of the 3 surveyed prices was chosen. The conclusion was that quotation effect focuses on the discount range of 5\% to 8\% in relation to the SINAPI median, Figure 11.

**Figure 11.** Setting quotation effect.

**Bargaining effect** corresponds to the discount obtained by buying in wholesale instead of in retail. 11 works were selected, among the ones chosen for analysis in quotation effect, to evaluate the influence of bargaining effect on the overall cost. Only large scale projects were selected, namely: infrastructure and paving works with higher overall cost up to 4 million Reais and buildings with higher overall cost up to 10 million Reais. The study showed that the bargaining effect represents an additional average discount of around 10\%, Table 2 (in Portuguese).

**Table 2.** Influence of bargaining effect on the overall cost (in Portuguese).
The authors also pointed out that the bargaining effect can be observed in smaller works, whose services have more quantities than Table 2. When associated with the quotation effect, the bargaining effect causes savings of approximately 15% of the overall cost estimated by SINAPI median.

4.4 Why Does Overbilling occur?

The difference between the Reference Cost and Real Cost pointed out by SILVA FILHO et al (2010) is similar to what MÁRIO LOPES (2014a and 2014b) called supercost. In Figure 8, MÁRIO LOPES (2014a and 2014b) showed that the overbilling caused by supercost has the same nature as the overbilling caused by the reduction of amount (or quality), but different origin and treatment: while this has its origin in execution and is considered fraud, that comes from the law and is considered legal.

Therefore, the supercost is systemic. MÁRIO LOPES (2014a and 2014b) explained that the Brazilian law defines concepts, directs the hiring scheme and limits the control tools, all in order to allow the emergence and to prevent fighting the supercost. It is the supercost that enables sub-referential overbilling, out of reach of auditing and control institutions and under the sacred mantle of law. Only a change in legislation would eliminate it.

According to MÁRIO LOPES (2014a and 2014b), the result is a “legal” enrichment scheme for hired companies, at the expenses of state impoverishment and penalty of its social function. Unpunished overbilling can turn into a source of funds for the payment of bribes and the financing of corrupt political campaigns. If the legislature is corrupted, it will not have any concern in changing legislation and the cycle is closed into a system, Figure 12.

5. OVERCOST AND OVERBILLING – A NUMERICAL EXAMPLE

To help clarify the relationship between Supercost and Overbilling, let’s use the following numerical ex-
ample extracted from MÁRIO LOPES (2014a and 2014b): The implementation of a 10m² masonry at a unit direct cost of R$ 42.00. 30% for BDI was adopted, leading to a unit price of R$ 54.60 in the bidding invitation. Under these conditions, the hired company presented a proposal with a unit price of R$ 52.00. During execution, there was a quantitative reduction to 8m². In the wholesale purchase, there was a decrease in unit direct cost down to R$ 36.00. With the replacement of materials by others of inferior quality, the unit direct cost was reduced once more to R$ 34.00.

When an audit was at work, it was possible to measure both the quantitative reduction (2m²) and the quality reduction (R$ 2.00). At the end, was there overbilling? How much was it?

Graphically, Table 3, corresponds to Figure 13. From highest to lowest, we see the Bidding invitation, Contract (winning bid), Reproduction and Real levels of a public work. The differences between the direct costs would be, respectively: discount, overcost and supercost. The differences between the prices would be, respectively: discount, overprice (which is considered fraud) and superprice. The cost of reproduction is the one necessary to reproduce a work identical to the analyzed work, obtained from measured quantities in the work and unit direct costs obtained in a reference system. In this example, the relationship between prices and direct costs is 1.3 (from 30% BDI).

In summary, relationship between costs and prices is shown in Figure 14 (MÁRIO LOPES, 2014a and 2014b). This Figure illustrates that, in the current audit form, it is regarded only a over-referential overbilling of R$ 124.80. This is overprice, originated in overcost (R$ 96.00). However, there is a subreferential portion of overbilling, corresponding to R$ 41.60, which is not considered by law. It is the superprice, originated in supercost (R$ 32.00).

**Table 3.** Direct costs and Prices from numerical example.

<table>
<thead>
<tr>
<th></th>
<th>Direct Cost (RS)</th>
<th>Price (RS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BIDDING INVITATION</strong></td>
<td>420.00</td>
<td>546.00</td>
</tr>
<tr>
<td><strong>CONTRACT</strong></td>
<td>400.00</td>
<td>520.00</td>
</tr>
<tr>
<td><strong>REPRODUCTION</strong></td>
<td>304.00</td>
<td>395.20</td>
</tr>
<tr>
<td><strong>REAL</strong></td>
<td>272.00</td>
<td>353.60</td>
</tr>
</tbody>
</table>

**Figure 13.** Unit direct costs and unit prices from numerical example.
6. OPINION OF EXPERTS

Some of the most renowned Brazilian experts in cost engineering have already pointed several problems in public work hiring system. We will mention just a few:

Aldo Dórea Mattos (2006)
- Government companies assume that all BDI is in the 25% range. This simplification ... embeds serious distortions in the budget, with impact on the hiring of the work.

André Pachioni Baeta (In: CARVALHO & PINI, 2012)
- Lack of information makes it necessary to use price reference systems;
- Budgeting parameters are fixed by law;
- Legal framework overestimates the basic design.

Mário Sérgio Pini and Luiz Freire de Carvalho (In: CARVALHO & PINI, 2012)
- Legal impositions generate mismatches, archaism and tabulating;
- Brazil is in a absolutist process of law;
- It is necessary to adjust the cost of reference tables.
There is a paradox related to the attempt to absolute control over public work costs, but that generates a complete ignorance regarding those costs.

Brazilian Engineering is under the realm of law.

7. CONCLUSION

Brazilian law (in theory) is designed to provide absolute control over the execution of public works. However, the result was to force the Government to hire public works with total ignorance over cost and price of public works as well as over BDI and profitability margin of hired companies.

Our legislation directs the hiring of execution of public works in a specific form: “work on contract” with overestimated cost and possibility of price addition, because discards the “work by administration” scheme and sets the reference cost in retail, as well as allowing for the possibility of price addition without change in object. This retail cost includes a dummy portion, which will not occur during execution of the work, and may end up being diluted between discount, overcost and supercost. The overcost matches the overprice; the supercost matches the superprice. Only the overprice is considered overbilling (fraud), while superprice (which has the same fictitious nature) isn’t considered the same: it’s legal. While overprice occurs above the reproduction price, superprice doesn’t. The overcharging (defining the overbilling) should be measured from the real cost of the work, considering both the overprice and the superprice, and not only from the reproduction cost. But, in the current form, this is not possible.

When Brazilian legislation sets the benchmark in the retail market, it creates a “parallel” market for public works, where hired companies can operate with retail cost, and this is not the real market, where competitiveness forces the use of the real (wholesale) cost. In addition, it minimizes the possibility of calculating real overbilling, which happens to be (in practice) only a reference overbilling. Overbilling not fought can turn into a source of funds for the payment of bribes and financing corrupt political campaigns. If the legislature is corrupt, it has no concern about changing the legislation and the cycle is closed into a system. The taxpayer pays the bill, being forced to live in a state whose social function is limited by the disappearance of resources that were already scarce in the first place.

The supercost, which gives rise to superprice, is responsible for the sub-referential overbilling and allows the diversion of public funds, in a “legal” way, passing out of the reach of control institutions. This status quo is not a coincidence, it was not done by those unaware of the matter, but it has a specific purpose: Maximizing profit (and minimizing the risk) of hired companies executing public works, especially the large ones.

The result is a “legal” enrichment scheme for these companies, at the expenses of the impoverishment of the state and the penalty of its social function. The existence of Supercost, therefore, may be legal, but it is immoral. Who thinks supercost is moral has no right to complain about lack of health, education, housing, security, transport etc. This is why, obviously, the state resources are limited. This is the fundamental economic problem. If the Government spends too much in one area, the social function of the state is hampered by a void that this excess causes in other areas.
Quoting MÁRIO LOPES (2014a and 2014b): “The budget truth is in the real price and the real price comes from the real cost.”

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Alignment of Contingency Definition, Concepts and Estimate Methodology

Macedo, H.C.; Ferreira, C.T.; Fonseca, F.C.R.; Braga, C.E.M.F.

ABSTRACT

In an increasingly competitive market with resources restrictions, becomes crucial that projects respect expected deadline and budget. Naturally projects are exposed to risks and uncertainties that may impact their performance and increase cost and/or schedule. Some of this risks can be treated or even avoided but some are not manageable. With the goal of organization resources optimization, risk management methodologies and tools are crucial to eliminate or minimize deviations.

In this context and seeking to increase the predictability of the resources needed for the project contingency calculation methodology can be used to fill this gap and allow project manager to keep the project progress within the planned cost and schedule. Contingency is used to absorb variations of wages, productivities, bulk materials quantities, equipment specifications and possible risks throughout the project life cycle. This paper will address the concept and methodologies to estimate cost and schedule contingencies on projects and differentiate it from other concepts such as allowance, accuracy range, management reserve, risk and uncertainty.

From the literature review of definitions given by institutions, such as AACE International, Project Management Institute - PMI, United States Government Accountability Office - GAO, this paper addresses the similarities and differences of contingency concepts, as well as the other concepts associated with cost and schedule estimation process.

As the contingency definition, its classification and application generates many doubts on decision makers, the present work aims to exemplify which categories are included in the calculation and which ones shouldn’t be considered.

The contingency calculation methodologies are presented focusing the advantages and disadvantages of each type, combination possibility among them and a contingency calculation example of an integrated cost-schedule risk analysis.
Finally the present study results in a clear compilation of concepts and categories applied to the contingency calculation. Besides that, it presents the relevance of cost-schedule integration in contingency calculation.

**Keywords:** contingency, management reserve, uncertainties, risk analysis.

**Introduction**

Project management in an increasingly competitive market has to consider risks and uncertainties that may impact projects performance and increase cost and/or schedule.

In this context, the main goal of companies is preservation of their cash flow and predictability of results. When the limitation on the treatment of risks is achieved, it is necessary the decision to adopt contingency values within the project feasibility and business tolerances. The management of this contingency plays an important role as a tool for project management. Therefore, it is necessary to establish a methodology to assist in the definition, calculation and control of contingencies throughout the project life cycle.

This paper includes the contingency definition of AACE, PMI, GAO, also detailing the items that are not considered in the project contingency. Some concepts related to this process will also be discussed in order to align the definitions.

The study also presents contingency calculation methodologies highlighting the advantages and disadvantages of each method in the project planning stages. The paper shows an example for integrated quantitative risk analysis method of schedule and cost to determine the project contingency.

**Definition**

Contingency is a subject handled by various institutions and authors of the project management area. In this paper, internationally recognized institutions were selected in order to get their definitions and alignment about the topic.

For AACE, contingency is an “An amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs. Typically estimated using statistical analysis or judgment based on past asset or project experience. Contingency is generally included in most estimates, and is expected to be expended.”

PMI define that “(...) Contingency reserves are the budget within the cost baseline that is allocated for identified risks, which are accepted and for which contingent or mitigating responses are developed. Contingency reserves are often viewed as the part of the budget intended to address the “known-unknowns” that can affect a project. For example, rework for some project deliverables could be anticipated, while the amount of this rework is unknown. Contingency reserves may be estimated to account for this unknown amount of rework. Contingency reserves can provide for a specific activity, for the whole
project, or both. The contingency reserve may be a percentage of the estimated cost, a fixed number, or may be developed by using quantitative analysis methods.

As more precise information about the project becomes available, the contingency reserve may be used, reduced, or eliminated. Contingency should be clearly identified in cost documentation. Contingency reserves are part of the cost baseline and the overall funding requirements for the project.”

According to GAO contingency reserve represents funds held at or above the government program office for “unknown unknowns” that are outside a contractor’s control. In this context, contingency funding is added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and experience shows are likely to result in additional costs.

Therefore, contingency is a provisioned amount or a time buffer for a project in order to cover any possible risks that may affect cost and/or schedule. It is included in the baseline of the project, which is calculated and added to the estimated time and cost of the project. Usually contingency tends to decrease with increasing maturity of the project and it is expected be consumed throughout the project execution. Its use can be controlled by the project manager, as proposed by PMI, and/or by a higher levels of the organization, according to GAO.

![Figure 1 - Cost Contingency.](image1)

![Figure 2 - Schedule Contingency.](image2)
Below there are examples classified as Project contingency:

- **Changes in the scope and development of engineering design or detailed.** It consists of small changes of scope, for example, the power increase of a pump throughout the engineering design detailing process.

- **Changes in market conditions.** Reduced number of suppliers, caused by the market crisis, resulting in increased of inputs value.

- **Variations in environmental conditions.** Rain occurrence above planned or adverse weather conditions that may impact the execution of the project.

- **Small price fluctuations.** Value variations of a particular input due to increased demand or freight oscillation cost because of fuel prices fluctuation. Small currency fluctuation.

- **Errors and omissions in the project planning or cost estimate.** Based on productivity changes and wage, uncertainties in quantities, cost units and adopted estimation methodology.

- **Risks associated with the selected technology.** When using a new technology in a process unit, there are unknown risks like construction, commissioning and startup.

Below there are examples that doesn’t fit as Project contingency:

- **Major changes in scope.** It consists of changes in the final product specifications, capacities, size of buildings and location of the asset or project.

- **Extraordinary events.** Major strikes, war, hurricane, natural disasters, etc.

- **Major changes in the planning.** Delay in mobilizing/demobilizing, reduction of time construction by extra working hours or greater mobilization.

- **Escalation and exchange effects.** It consists in currency oscillations by exchange fluctuations and escalation (includes prices inflation and deflation). This one is usually treated as a contractual clause to repayment for economic and market variations.

- **Exceptional Stand-by.** Addresses the extension of time of a support team during the assisted operation process of the industrial plant.

- **Major changes on contracting strategy.** Changes on contracting strategy could mean very different types of contracts. For example, a refundable contract is completely different from an EPC (Engineering, Procurement and Construction) contract, because in the first case risks are owner's responsibility, while in the second one all risks are transferred to contractor.

- **Management reserve and Allowances.** Are detailed on next topic.
The next table resume the itens covered or not by contingency.

**Table 1 - Examples of itens covered or not by Contingency**

<table>
<thead>
<tr>
<th>Not included on Contingency</th>
<th>Included on Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major changes on contracting strategy.</td>
<td>Changes in the scope and development of engineering design or detailed.</td>
</tr>
<tr>
<td>Extraordinary events.</td>
<td>Changes in market conditions.</td>
</tr>
<tr>
<td>Major changes in the planning.</td>
<td>Errors and omissions in the project planning or cost estimate.</td>
</tr>
<tr>
<td>Escalation and exchange effects.</td>
<td>Variations in environmental conditions.</td>
</tr>
<tr>
<td>Exceptional Stand-by.</td>
<td>Small price fluctuations.</td>
</tr>
<tr>
<td>Major changes in scope.</td>
<td>Risks associated with the selected technology.</td>
</tr>
<tr>
<td>Management reserve and Allowances.</td>
<td></td>
</tr>
</tbody>
</table>

By the table, there are no clear limits established, for example, what would be a small price fluctuation? As each project has specific characteristics, it's important to organizations create procedures to bound what can be considered as contingency.

**Other Contingency-related Concepts**

For a better understanding of contingency concept, it's necessary stablish the difference from others concepts such as risk, uncertainty, accuracy range, management reserve and allowance. Therefore, those definitions, adopted by institutions, are presented below:

**According to AACE:**

**Accuracy Range** - “An expression of an estimate’s predicted closeness to final actual costs or time. Typically expressed as high/low percentages by which actual results will be over and under the estimate along with the confidence interval these percentages represent.”

**Allowance** - considered “for estimating, resources included in estimates to cover the cost of known but undefined requirements for an individual activity, work item, account or sub-account. For scheduling, dummy activities and/or time included in existing activities in a schedule to cover the time for known, but undefined requirements for a particular work task, activity, account or subaccount.”

**Management Reserve** - “An amount added to an estimate to allow for discretionary management purposes outside of the defined scope of the project, as otherwise estimated. May include amounts that are within the defined scope, but for which management does not want to fund as contingency or that cannot be effectively managed using contingency.”

**Risk** - “An uncertain event or condition that could affect a project objective or business goal.”

**Uncertainty** - “The total range of events that may happen and produce risks (including both threats and opportunities) affecting a project.”
According to PMI:

Accuracy Range - For cost is “the acceptable range (e.g., ±10%) used in determining realistic activity cost estimates is specified, and may include an amount for contingencies.” For schedule is “the acceptable range used in determining realistic activity duration estimates is specified and may include an amount for contingencies.”

Management Reserve - For cost is “an amount of the project budget withheld for management control purposes and are reserved for unforeseen work that is within scope of the project. Management reserves are intended to address the “unknown unknowns” that can affect a project. The management reserve is not included in the cost baseline but is part of the overall project budget and funding requirements. When an amount of management reserves is used to fund unforeseen work, the amount of management reserve used is added to the cost baseline, thus requiring an approved change to the cost baseline.”

For schedule is “(...) a specified amount of the project duration withheld for management control purposes and are reserved for unforeseen work that is within scope of the project. Management reserves are intended to address the “unknown-unknowns” that can affect a project. Management reserve is not included in the schedule baseline, but it is part of the overall project duration requirements. Depending on contract terms, use of management reserves may require a change to the schedule baseline.”

Risk - “is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality. A risk may have one or more causes and, if it occurs, it may have one or more impacts. A cause may be a given or potential requirement, assumption, constraint, or condition that creates the possibility of negative or positive outcomes.

(...) Project risk has its origins in the uncertainty present in all projects. Known risks are those that have been identified and analyzed, making it possible to plan responses for those risks. Known risks that cannot be managed proactively, should be assigned a contingency reserve. Unknown risks cannot be managed proactively and therefore may be assigned a management reserve. A negative project risk that has occurred is considered an issue.”

According to GAO:

Management Reserve - “Management reserve funds (...) are for “known unknowns” that are tied to the contract’s scope and managed at the contractor level. Unlike contingency reserve, which is funding related, management reserve is budget related. The value of the contract includes these known unknowns in the budget base, and the contractor decides how much money to set aside.”

Risk – “is the chance of loss or injury. In a situation that includes favorable and unfavorable events, risk is the probability that an unfavorable event will occur.”

Uncertainty – “is the indefiniteness about the outcome of a situation. It is assessed in cost estimate models to estimate the risk (or probability) that a specific funding level will be exceeded.”
According to the definitions of AACE and PMI, it is understood that the differences between contingency and management reserve are that contingency is an amount that is within the project baseline, unlike the management reserve which is focused on the management of project portfolio. Therefore, this money can be used for a portfolio of projects and requested through a change request process, and if approved by a higher level of the organization, leads to changes in the project baseline. However, the contingency budget has its management performed by the project manager and its use associated with occurrence of known events (risks) and uncertainties. The definition of management reserve by GAO is different from those by AACE and PMI, because for GAO the management of this reserve is the responsibility of the contractor.

The allowance differs in some points from the contingency, as defined by AACE. The first difference is that allowance is a percentage calculated and applied during the preparation of the project’s cost and schedule estimates. This percentage refers to a part of the scope that is known, but was not measured, because there wasn’t sufficient details or its quantification may not be economically efficient. The contingency is aggregated after the preparation of cost and schedule estimates and is linked to uncertainties and project risks. Allowance will be consumed during the execution of the project, while the contingency may be partially used. Allowance is used only on detailed cost and schedule estimates, not being applicable on conceptual estimates (eg, parametric estimate). The contingency can be applied to detailed or conceptual estimates.

The concepts of allowance, contingency and management reserves are summarized in Figure 3 below. By the figure, you can see cumulative distribution function curve of the project cost. When contingency is added to the estimate, there is a higher probability of not happening the cost overrun.

![Figure 3 - Allowance, Contingency and Management Reserve.](image-url)
The uncertainties and risks that the project is subject implies the need to establish a contingency to prevent overrun of time and cost.

Figure 4 - Probabilistic Curve Variability based on Project Maturity.

Uncertainties are related mainly to the estimation process, such as variations (wage, productivity, quantitative), the estimator experience and the estimation method. So, in a probabilistic curve of the project cost obtained from risk analysis method (see section Integrated cost-schedule risk analysis), as in Figure 4, the higher the level of uncertainty implies a smaller accuracy range (higher confidence interval), probably due to a project lower maturity level. For example, in Figure 4 - Probabilistic Curve Variability based on Project Maturity, the project A (blue curve) has a higher level of maturity than the project B (orange curve), meaning a higher confidence interval of project B.

In addition to the project's uncertainties, risks associated with the project scope shall be taken into account. When the risks are considered, there is a potential variation in the probabilistic curve of the project cost (blue curve Figure 5). This new curve indicates how much the cost and/or schedule of the project may vary from the occurrence of risks.

From the result of the risk analysis the project manager can set a percentile (eg, P50 or P80) that will represent a percentage of contingency to be used in the project. The criteria for choosing appropriate percentiles of contingency for schedule and cost should be defined by the organization. In the example of Figure 5, the chosen percentile is P50% indicating a contingency of 7% over Deterministic Value.
In a project’s early phases, knowledge is imperfect. Cost estimates are more uncertain at the beginning of a project, because less information is known about its scope. In the early phases only general requirements can be defined for the project and there is a bigger probability of scope changes. Also, while detailing the cost estimate, usually cost estimate grows.

Since the contingency amount results from the scope definition, the level of project information knowledge is inversely proportional to the cost contingency percentage allocated to the point cost estimate. (See Figure 6)

![Figure 5](image_url)

Figure 5 - Red Curve: Probabilistic curve of the project cost. Represent a probabilistic distribution of uncertainties from estimate process; Blue Curve: Probabilistic curve of the project cost (Risk + Uncertainties). Represent the project’s probabilistic distribution caused by risks and uncertainties.

![Figure 6](image_url)

Figure 6 - Changes in Cost Estimate according to maturity.
**Contingency calculation methods**

In the literature four classes of methods are usually found for cost and time risk estimates. The application of these methods has advantages and disadvantages according to the project maturity level. Therefore, the literature recommends the application of hybrid methods that combine two or more methods in order to increase reliability of results. The methods are listed below:

- Predetermined Percentage;
- Expert Judgment;
- Parametric Modeling;
- Risk Analysis.

**Predetermined Percentage:** consists in adopting a predetermined contingency percentage to be added to the cost and schedule estimate for all projects or for each project type. Normally, the percentage number is recorded in the corporate procedures of each company and can be obtained from predetermined tables. For instance, a contingency percentage defined as 10% in a R$ 10 million project results in a cost contingency of R$ 1 million.

**Advantages:** easy application can be used during the entire project phases.

**Disadvantages:** it can’t capture specific risks of the project; since this method doesn’t relate risks events and contingency amount, it may be difficult to control the contingency cost use; although this method is applicable to all project phases, it is recommended to apply in early project phases.

**Expert judgement:** from an expert’s opinion based on his previous experience in project management and risk analysis is defined a contingency percentage or amount for time and cost contingency. It is recommended obtaining opinion from multiple experts in order to avoid inconsistency and minimize bias.

**Advantages:** easy application can be used during the entire project phases and it is normally used in hybrid combination with others methods.

**Disadvantages:** the application of the method requires qualified and experienced professionals; it may not capture all specific risks of the project; the expert judgement can be inconsistent or biased.

**Parametric Modeling:** based on a project information database is possible to generate a parametric model in order to calculate cost and time contingencies. With technical data, such as, production capacity, unit type, and costs it is possible to establish correlation among variables and, consequently, define appropriate contingency for the project. The method uses multivariable regression analysis in order to define correlation coefficients of the equation. For example:

\[ \text{Outcome} = \text{Constant} + \text{Coefficient 1} \times (\text{Parameter A}) + \text{Coefficient 2} \times (\text{Parameter B}) + \ldots \]

The outcome can be an amount for cost or time contingency, the parameters represent project data (e.g. technology, production capacity, etc.) and the equation may be linear, logarithmic, exponential, power or polynomial.
Advantages: easy application (after the definition of parametric equation); more precise than the two previous methods presented. The method takes into account project systemic risks, that is, risks that are not unique to a particular project. These are risks connected to, e.g., company culture, technology adopted, complexity, among others.

Disadvantages: the method requires reliable project database; the model definition requires considerable amount of time; the model may vary depending on the project type; it is necessary qualified professionals for the model definition; although this method is applicable to all project phases, it is recommended to apply in early project phases; it may not capture all specific risks of the project.

Risk Analysis: based on the integrated cost-schedule risk analysis. It is a detailed method and requires expert’s opinions and observations to qualify risks, opportunities and to define impact and occurrence probability.

Advantages: the method allows the identification of project specific risks, it correlates risks events and contingency, it is more accurate than previous methods presented in this paper and provides information necessary to increase contingency control level.

Disadvantages: it is most applicable for more detailed project phase; it requires qualified and experienced professionals for the analysis execution; it is necessary involvement of all project team members.

The method may be applied to define integrated cost-time contingency. It’s a highly recommended method because it includes the impact of schedule risk on cost risk and provides more realistic results.

Integrated cost-schedule risk analysis

The integrated cost-schedule risk analysis is based on integrated cost-schedule estimate by resource loading and costing the schedule’s activities. The method provides an integrated risk analysis using Monte Carlo techniques and presents multiple cost-time results for the project.

In order to apply this method is necessary a consistent cost and schedule planning. The WBS (work breakdown structure), CBS (cost breakdown structure), cost estimate and schedule must be compatible to each other. Experience shows that the majority of cost risks are, actually, the effect of schedule risks on costs.

- The main inputs to the analysis are listed below:
  - Cost estimate free of any specific contingency, no risk impact must be included in the cost items;
  - High quality resource loaded schedule. The schedule must also be updated and logically linked (the schedule should not contain open activities and lags should be avoided);
  - Reliable and consistent risk data with probability and impact loaded;
Compatibility between cost estimate and schedule. It's not uncommon to find conflicting cost and schedule estimates. These makes the risk analysis very difficult or even impossible to be executed.

The method uses a summary level schedule (for example 100 – 500 activities) rather than a detailed schedule because the cost-schedule risk analysis is a strategic tool, not a schedule control tool.

The integrated method has a more complete approach because it presents the influence of schedule risk on cost risk and, thus, provides a better understanding of the influence of schedule variation on cost variation.

The result of the analysis is useful only for the current plan. A new plan might (or must) emerge based on a risk analysis. The analysis results support the project team to anticipate and answer appropriately to the risks generating a new plan.

Since risk has a positive or negative effect on, at least, one of the project constraint (time, scope, cost or quality) the risk analysis must address all constraints in the planning phase (Figure 7).

Information about uncertainties and risks must be collect from risk specialists in a structured interview. Risk information of the project is then translated by identified and quantified risks. Generally, the resources and costs are given a 3-point estimate (optimist, most likely and pessimistic) to address uncertainties and risks. Some risks, in addition to 3-point estimates, are quantified by their probability of occurring. In Monte Carlo simulation, these risks will occur depending on its probability. If the probability of a certain risk is, let say, 30% then it will occur in a randomly chosen 40 percent of the iterations. It's mandatory to consider both “uncertainties” and “risks” in the simulation.

In this paper we will use a simple project as an example, the following case study is for teaching purposes only.

A simple project with 11 activities, R$ 939,000 point cost estimate and 10-month is shown on figure Figure 8 below.
Figure 8 - Project with 11 activities.

Loading "uncertainties" and "risks" into the project schedule loaded with costed resources, for the purpose of integrated cost-schedule risk analysis is an important step of the simulation process and must represent the reality simulated.

The integrated cost-schedule risk analysis uses Monte Carlo simulation tools and produces, among other outputs, cumulative distribution for Finish Date and Cost. See below.

Figure 9 - Cumulative Distribution - Finish Date.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Deterministic</th>
<th>P10</th>
<th>P50</th>
<th>P90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>29/04/2017</td>
<td>23/04/2017</td>
<td>13/05/2017</td>
<td>04/06/2017</td>
</tr>
</tbody>
</table>
The results indicate the finish date probabilities of the project. In 90% of the iterations the finish date is up to 04/06/1917.

### Figure 10 - Cumulative Distribution – Cost.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Deterministic</th>
<th>P10</th>
<th>P50</th>
<th>P90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>R$ 939,000</td>
<td>R$ 890,193</td>
<td>R$ 1,003,053</td>
<td>R$ 1,129,273</td>
</tr>
</tbody>
</table>

If the P(90) is considered the total cost amount of the project, it is defined R$ 190,273 of cost contingency for the Project.

The time-cost scatter diagram below shows both total cost and finish date of the iterations. Axis x represents the finish date and axis y represents the total cost. Each point represents one result of the iteration and is defined by a finish date and total cost estimate.
The lower-left quadrant of the scatter plot indicates 22% chance that at the end of the completion, both cost and schedule deterministic plan will be satisfied.

A company strategic committee should make the decision of the adequate percentile that define cost and finish date for the Project. The decision should be based on both internal and external information and must consider economic, technical and environmental factors.

After the risk analysis process and cost contingency definition, the amount of the cost contingency must be controlled by the project manager. Each part of the cost contingency is addressed to a identified risk event, and its use must be according to the risk event occurrence during the project cycle life. If a risk event does not occur, the amount of cost contingency associated to this event must return to the company fund.

In the occurrence of unknown and not covered by the cost contingency risks, the amount necessary to mitigate the cost generated by these events must be obtained from the management reserve fund with the authorization of the company board.

**Conclusion**

Although the paper do not intend to exhaust the subject contingency, this work collaborate with an alignment of its definition and other concepts related to the subject. Therefore, the study provides a source for organizations and stakeholders related with project management, at one place, the vision of different associations specialized.
Due to the different characteristics of business, culture, values and goals of the organizations it is up to each of these the establishment of procedures to deal with methodologies, tools and definitions for contingency management of schedule and cost, that meet the needs of each company. Therefore, different ways of calculating the contingency were presented highlighting its advantages and disadvantages so each organization can define the best method to be used in their projects.

The study exemplified the integrated risk analysis methodology of cost and schedule, because method includes the impact of schedule risk on cost risk and provides more realistic results.

The calculation of contingency during the execution phase of the project wasn’t the objective of this paper. It focus on the conceptual and basic phases, i.e., initial project planning. As a development proposal for future work, it is suggested the study of contingency management at project execution phase, because in this phase there are two views on the subject (owner and contractor).

References

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AACE International Recommended Practice No. 57R-09, 2011, Integrated Cost and Risk Analysis using Monte Carlo Simulation of a CPM Model.


Forecasting Engineering Design Project Errors

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ABSTRACT

Knowledge retrieval has been recognized as a key issue in engineering design projects. A great amount of design information is generated during design verification steps. Engineering documents are generally verified using checklists. These checklists have a long list of items which need to be checked against the document being reviewed. The engineer or designer needs to check each item on the checklist in order to determine whether the document is suitable for approval.

Checklist records can become more useful if they generate a database which can be retrieved and used in forecasting models, enabling avoidance of future design mistakes. These forecasting models aim to enhance the projects performance by reducing future corrective actions, which are time-consuming and costly.

The objective of this paper is to improve the performance of engineering projects by reducing design corrections with the help of an expert system. This expert system’s role is to capture the expert’s knowledge, design information and data from the verification checklists; and then, process the collected data in order to anticipate potential design projects mistakes. In addition, this expert system has been validated with an engineering design project company.

Keywords: Expert System; Knowledge Database; Engineering Design Projects; Forecasting Model.

1 INTRODUCTION

The need to compress project schedules has put pressure on traditional engineering projects. It is clear that there is still a need for innovative research in the area of engineering design projects.

Design verification represents an essential step in engineering design projects. The verification purpose is to ensure that all design tasks are completed in accordance with the specifications or are carried out in accordance with appropriate standards and methods.

Once documents are verified through electronic checklists, a computer system is able to use the database to provide information that improves design project performance.
This paper proposes an innovative expert system to capture data from the electronic checklists and then, use the expert knowledge to process the collected data in order to anticipate potential design projects mistakes. The approach demonstrates to be efficient in terms of reducing time and cost of engineering design projects once it increases the document elaboration accuracy and decreases man-hour used in verification and revision steps.

Literature on similar subject, i.e., engineering design error prediction is unknown. Thus, this work can be considered extremely innovative.

The remaining parts of this paper are organized as follows: Section 2 introduces the methodology. Section 3 presents the implementation. The results are discussed in Section 4. Finally, Section 5 draws some conclusions.

2 METHODOLOGY

An Expert System [2, 4] is a problem solving and decision making system based on logical rules and historic database. These expert systems represent the expertise knowledge as data and rules which can be called to solve problems.

In this paper, the expert system roles have been designed to capture the knowledge of the experts and the data of engineering design checklists. After that the system is able to process these data and form rules to present alert with potential design errors. Figure 1 illustrates the system model.

![Figure 1. The Expert System Model](image)
There are two main parts to the expert system: gathering the raw data and rules definition.

2.1 Gathering the Raw Data

Design documents in engineering projects passes through a standard workflow composed by activities executed in a certain order with one professional responsible for each step, beginning with execution/design, following to verification and revision and concluding with document's issuing, as demonstrated in Figure 2.

![Figure 2](image-url)  
**Figure 2.** Engineering Document Workflow Model

When the document reaches the verification stage, a senior engineer or designer will verify that document using a verification checklist, an auxiliary tool composed by several questions that need to be attended according to appropriate standards, methods and client’s specifications.

As the verification stage finishes and all questions are answered, the professional will advance the design to the next activity or, in case of required corrections, document will be returned to revision stage, where another professional will correct errors found. This process can be redone as many times as necessary, until the document has no more errors, being known as verification cycle.

As checklists are filled, the expert system creates a database with complete information about what is being answered on those checklists, compiling all data such as total errors by discipline, document type and professionals profile. With all this data at disposal, the system can now analyze the patterns and tendencies, tracing parameters for detection of potential future errors.

2.2 Rules Definition

While analyzing the data acquired, the expert system will create a ranking of the most common errors ordered by professional profiles and documents characteristics; then will apply conditional rules to define
the alert for each user about the most probable design errors.

In the first moment the system will try to select most frequent errors for the specific professional and document features, as showed in Figure 3. Although, if there are no representative checklist records in the database for this filter, the system will reduce the constraints, considering errors for similar professional profile and document characteristics.

After the data selection, the system shows an alert box, containing most probable errors, advising the user to be careful about these mistakes while designing the document.

![Figure 3. Rules Definition for displaying alerts](image)

### 3 IMPLEMENTATION

In this work, the expert system was implemented inside an electronic document management system (EDMS) [3], called SAPROD [5], currently being used by design engineering companies. EDMS is a type of software that electronically manages the document lifecycle. It enables a detailed control of documents workflow and provides indicators related to process quality and professional productivity.

As the designer concludes the design elaboration, the document will proceed to the verification stage through the system workflow. The person responsible for design verification must fill up the electronic checklist, embedded in the system, in order to proceed to the next stage, as showed in Figure 4.
After checklist errors database creation, new alerts will be displayed, before elaboration stage is started, as presented in Figure 5. The alerts show most probable errors, based on professional profile and document characteristic. Through this alerts, system helps to prevent similar errors in the project.
The designer must confirm the alert information, by clicking in a button “Ok, I'm aware”. The confirmation is stored in the system for future consulting.

4 RESULTS

The proposed approach has been tested in a real scenario. A design engineering company that uses the software SAPROD, allowed a study involving two very similar projects undergoing simultaneously. The expert system has been used in one project to predict the design errors while the other project followed the standard process. This analysis allowed an effective demonstration of the methodology results.

When comparing both projects performance, it has been verified that the project with error forecasting methodology had a reduction of 16% in percentage of checklist items with error. It has been considered only the checklists filled in the first verification cycle for each design document, i.e., it has not been considered the checklists filled after the document revisions.

Figure 5. Potential Error Alert
Another indicator is related to the reduction of verification cycles. Project with error forecasting method had a decrease of 20% in average of verification cycles per document, as presented in Figure 7.

As less workhours were spent in verification and revising stages, it has been verified a reduction of approximately 6.4% in the design project cost and duration.
5 CONCLUSIONS

In this paper, an expert system is presented to manage verification checklist database in order to anticipate potential design errors, before the design elaboration.

Expert Systems are artificial intelligence [1, 6] tools that apply the expertise of knowledge workers in a database and provide advice to non-experts in a given domain.

The methodology has been implemented in a commercial electronic document management system (EDMS), called SAPROD, which control documents workflow and enable electronic checklists for document verification stage. Once the checklists are recorded in system database, expert rules are used to select the most frequent error for each professional profile and document feature, showing alerts to the designer before the document beginning.

A case study was analyzed to illustrate the benefits of the developed method. The results confirmed a reduction of cost and time for engineering design project that considerer the proposed approach.

BIBLIOGRAPHY


Stakeholders and the Search for Appropriate Foundations of Public Policy Criteria

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ABSTRACT

Purpose of this paper

This article analyses the relevance of stakeholder’s definitions in public policy. Using the example of short, medium and long-term childhood education capacity, the specific objective is to understand how to improve its methodology and create more suitable legal instruments for measuring the range of education policies and programs.

This article aims to demonstrate how inconsistent are the numbers taken into account by Rio’s government to evaluate the capacity within childhood. In order to achieve this goal, techniques for cost assessment and stakeholder definition will be applied using different criteria.

Methodology

We first studied setting parameters when evaluating the stakeholder income bands by evaluating the various criteria used for different social programs. We then studied the impact of child education costs on other related stakeholders. A survey was carried out on facility construction costs of childhood education, existing urban land legislation which requires mandatory public involvement, different social programs such as Bolsa Familia and Minha Casa Minha Vida and Carioca Social-Demographic profiles used in public programs.

Essential information and figures were obtained from the most relevant public agencies, mainly the Secretary of Education of the municipality of Rio de Janeiro and The Brazilian Institute of Geography Statistics (IBGE).

Results found

Research indicates the need to enhance the standard setting of the beneficiaries of social programs and how developers can better contribute to the expansion of the public school network.
The lack of appropriate criteria can result in a distorted or at least limited view of stakeholder requirements; and allow for the creation of laws and programs not always in the public interest.

The practical objective of this research is to foster new legislative practice and policy creation which promotes the establishment of a better goal for educational infrastructure or any other public target.

Value of paper

The research reveals existing instruments which yield more effective and transparent public policy that are not currently in use which contribute to the political decisions and law proposals in the Legislative House, mainly those related to education, urban development and low income construction.

Key words

stakeholders, public policies, education, housing, urbanism

INTRODUCTION

“The Constitution of the Federative Republic of Brazil Art. 1 ......Single Subsection-All power comes from the people, whose actions are expressed by elected representatives or directly, in accordance with this constitution.”

The practical application of stakeholder theory within project management occurred only in the nineties through the implementation of Corporate Social Responsibility, widespread today in companies around the world (Fields, 2002). For some experts such as S. Freeman, the stakeholders justify the very existence of the company. For others such as Friedman, the stakeholders are important to the extent of their influence on organizational performance.

According to Martos and Martos (2012) the term has its origins in the nineteen sixties, but the most commonly accepted definition came from philosophers Robert Edward Freeman and David Reed.

In Freeman’s definition (1984), which is used by the PMI (Project Manager Institute), the term stakeholder can be understood as:

People, groups or organizations that could impact or be impacted by the project.

Freeman’s definition is criticized for its scope because it would cover an infinite possibility of influence, including things such as climate and nature (STARIK apud CAMPOS 2002).

According to Mitchell, Agle and Wood (1997), organizations can identify their constituents from the responses to questions across three dimensions (or attributes): power, legitimacy and urgency:

The attribute power (to influence the organization) can be understood as the extent to which individuals or groups are able to persuade, encourage or exert pressure on other individuals or groups to undertake
certain actions;

Legitimacy implies the existence of a contractual relationship that creates the ties between stakeholders.

Urgency is a multidimensional attribute, which introduces dynamism to the choosing of constituents and makes it difficult to complete. It indicates the degree to which the organizational constituents want immediate attention.

When it comes to Atkinson and Waterhouse (1997) they established two types of stakeholders. Primary stakeholders are essential to the survival of the company and secondary stakeholders, who's influence does not compromise the existence of the organization.

As Martos shows, in the framework of enterprise, despite the majority view, the focus on initiatives that aims to enhance the Stakeholder's importance is not consistent. However, in this paper we will use a principle backed by the constitution: the absence of state itself without the Stakeholders (as stated in art.1º).

As teacher Carlos Roberto M. Pellegrino teaches:

“Let it be clear that primarily any insinuation of State superiority over the legitimate will and determination of the people is intolerable as it is the reason that the state exists”

THE STAKEHOLDERS ACCORDING TO THE STATE

From the point of view of Constitutional Law (LEGAL DICTIONARY 2002), the State is a legal political organization that stems from the fact that people live in a territory outlined and governed by laws founded by a sovereign power. Therefore, in principle, the population is the main stakeholder. On the other hand, in technical terms, it is not of much added value do declare such a broad and generic stakeholder.

Furthermore, Joom Chang (2010) reminds us that the government decision-making process is much more complex than any financial institution and involves a great diversity of demographic groups of all sizes. The author therefore also asserts that the complexity of decision making increases in democratic regimes.

In accordance with the PMBOK (5th edition), the overview of the management process of interested parties includes the following steps:

Identify Stakeholders—The process of identifying the people, groups or organizations that could impact or be impacted by a decision or other actions;

Plan Stakeholder Management—The process of developing appropriate management strategies to effectively engage stakeholders throughout the project life cycle;
Manage Stakeholder Engagement—The process of communicating and working with stakeholders to meet their needs and/or expectations or other actions;

Control Stakeholder Engagement—The process of monitoring overall project stakeholders and other actions.

Among the techniques suggested are: analysis of interested parties, consultation with experts and meetings.

For this article we will focus on the first step - Identify Stakeholders- and the techniques that establish classification models such as the following:

- Power/interest grid, grouping the stakeholders into two groups based on their level of authority ("power") and their level of:
  ◊ concern ("interest") regarding the project outcomes;
  ◊ active involvement ("influence") in the project.

- Influence/impact grid, grouping the stakeholders based on their active involvement ("influence") in the project and their ability to effect change on the project’s planning or execution ("impact");

Model of relevance which describes the types of interested parties based on their power (capacity to impose their will), urgency (the need for immediate attention) and legitimacy (with appropriate involvement).

From the list above we highlight the degree of interest, the impact and relevance of the techniques, all of which are key elements for the subsequent analysis.

The stakeholders’ function varies according to its role in time and space. A good example of time would be when the citizen pays their tax they are a government sponsor and when they receive the public service they are a customer. The space respect to its position within the criteria of program structure. An example of space would be the development of a facility for low-income families with emphasis on low-cost housing construction. At first, the stakeholders will include construction and financing firms, central government, local government and politicians in addition to the target audience, the principle stakeholder. This issue highlights the central theme of this article: how to assess the key state action groups within the Stakeholder structure?

The basis for this article is Rio de Janeiro’s public education programs within the development of childhood education facilities.

In the last ten years we have seen an increase in the understanding and appreciation of childhood education as an essential element in personal development. This new status is demonstrated in laws and programs targeted at children aged up to six years. For childhood education to be thoroughly inclusive,
the government needs to constantly study this age group in order to best create educational plans and goals which meet its demands. The services in child education policy include the construction of facilities and the expansion of its capacity. Therefore, the administration of Rio de Janeiro creates legal provisions that require the private sector to cooperate with these practices, which are called counterparts, actions to be evaluated in this text.

The establishment of measurements for required childhood education space, and therefore the service to its stakeholders, proved to be a complex task since it needed to find consistent reference parameters within the target public.

One of the initial forms found to evaluate the lack of space in day-care is on the Sustainable Cities website (http://indicadores.cidadessustentaveis.org.br/br/RJ/rio-de-janeiro/demanda-atendida-em-creches). This site details the 2015 registrations fulfilled: 52,818 against registrations requested: 75,267 with the difference equating to a shortfall of 22,449 spaces. This reference obviously does not expose the real demand since the lack of vacancies in childcare is not only reflected in enrolment requests (demand from stakeholders), but also from broader criteria. Amongst these further criteria we will restrict ourselves to studying those dealing with economic factors and age groups (up to six years old). As a reference to my further analysis the reader should bear in mind the following: among six private nurseries surveyed in Tijuca, the monthly cost for full time care was between BRL $ 1,000.00 and BRL $ 2,000.00 (September 2015 USD to BRL $ 3.85).

According to the 2010 IBGE data, the population of the city of Rio de Janeiro has approximately 450,000 children in said age group, or 7.11% of Rio's population. We must however exclude from this group those that use private child education establishments, remembering that all citizens have the right to free education regardless of income (Resolution no. 5/2009 of the CNE). It remains reasonable to expect that a child insertion program within early childhood education should fundamentally consider lower income bracket sectors of the public. For this reason, we tried to define which sectors should be prioritized and ensure at least one stakeholder included poor families. We therefore now need to define how we will determine “low-income” for the sake of this study.

A first reference could be the one used for the granting of Bolsa Família (a program that provides monthly basic income), as found in the Federal Decree 5,209 of September 17, 2004 and as amended by Decree no 8.232 of 30 April 2014:

“Art. 18. The Family Grant Program will serve families in poverty and extreme poverty, with monthly family income payments per capita of up to BRLS 154.00 (one hundred and fifty-four reals) and BRLS 77,00 (seventy-seven reals), respectively.”

The information from 2010 IBGE (Rio de Janeiro) did not define this income range, however a sample of households with income below half of the minimum wage, a little more than R$380.00 (three hundred and eighty) per month, only resulted in 4,800 children aged 0 to 6 living in the city of Rio de Janeiro. This is an extremely small group considering the number of families who need to receive the services of child education.
The expansion of the pool of potential beneficiaries could include those favored in other programs for the low income population such as the program Minha Casa, Minha Vida. The Decree no 7.499 from 16th of June 2011 that “Regulates sections of Law No. 11.977 from 7th of July 2009”, which in turn “deals with the program Minha Casa, Minha Vida and makes other provisions” describes:

“Art. 1 Minha Casa, Minha Vida program PMCMV aims to create mechanisms to encourage the production and purchase of new housing units, the upgrading of urban real estate and production and refurbishment of rural housing, for families with monthly income of up to R S 5,000.00 (five thousand reals)”

The value assigned above amounts a little more than six times the national minimum wage. This income limit accounts for almost 265,000 children in the city of Rio de Janeiro.

The Municipal Education Plan, Law no. 4.866, 2 July 2008, which “approves the Municipal Education Plan and makes other provisions”, uses as a parameter for the definition of poor households those in which the head of the family receives less than two times the monthly minimum wage, totaling approximately 104,500 children below the age of six.

Rio de Janeiro, through Decree no. 33.642, of 6 April 2011, that “Changes the parameters of framework for obtaining the benefits of Complementary Law no. 97/09”, which in turn “establishes standards for buildings and developments related to social interest enterprises linked to municipal, state and federal housing policy and makes other provisions” establish the parameters for obtaining the benefits:

“Art. 1 To obtain the benefits of Complementary Law No. 97/09 and the Laws 5065/09 and 5066/09, in the projects of social interest linked to municipal, state and federal housing policy, 70% (seventy percent) of units should meet the maximum value of purchase or sale defined by the Federal Government, without exceeding the value of financing defined as the ceiling for families with an income of up to ten times the minimum wage.” “(emphasis added)"

Using the latter parameter to define the benefit group highlights the lack of educational services as 345,000 children would qualify for early education program, but the capacity would only cover just 17% of this group.

In accordance with Rio de Janeiro’s strategic planning, local government will open in 2016 sixty thousand spaces for child education. Considering information available on the Municipal Secretary of Education website (http://www.rio.rj.gov.br/web/sme/exibeconteudo?id=125527) 40,585 spaces have already been created therefore capacity is expected to reach 19,500 children by next year surpassing the spaces requested in 2014 of 75,267.

The difficulty in establishing which income measure to use is clearly reflected in the Student Financing Fund-FIES. They used as a parameter for providing services people with gross monthly family income of up to twenty times the national minimum wage but then had its rule amended to just two and a half times the national monthly minimum wage per capita (currently this measure corresponds to BRLS1,756.00)
Table 1 - Lack of places for children according different official criteria (Author’s table)

<table>
<thead>
<tr>
<th>Institute</th>
<th>Description</th>
<th>Income Criteria</th>
<th>Demand * (2)</th>
<th>Deficit * (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolsa Familia</td>
<td>Law defines the criteria for poverty and extreme poverty</td>
<td>up to 150 reals</td>
<td>4,800 * (4)</td>
<td>0</td>
</tr>
<tr>
<td>PMCMV * (5)</td>
<td>Defines in law the beneficiaries of the program</td>
<td>up to 5 thousand reals</td>
<td>265000</td>
<td>204,915</td>
</tr>
<tr>
<td>Municipal Education Plan</td>
<td>Established in Municipal SME-Education Plan, Law No. 4866 of July 2, 2008</td>
<td>up to 2 minimum wages</td>
<td>104500</td>
<td>44,415</td>
</tr>
<tr>
<td>Benefit Law No. 97/09</td>
<td>Set in Municipal Law the housing projects exempt from compulsory counterpart donations</td>
<td>up to 10 minimum wages</td>
<td>345000</td>
<td>284,615</td>
</tr>
<tr>
<td>citiesSustentáveis.org</td>
<td>Comparing the demand for jobs in 2014 with the number of vacancies in the same year.</td>
<td>Pre-registration * (6)</td>
<td>75,267 (vacancies requested)</td>
<td>22,440</td>
</tr>
<tr>
<td>FIES- current limit</td>
<td>The previous limit was 20 times minimum wages. Sets the range that receives funding for private higher education within Federal Standard.</td>
<td>up to 2 times minimum wages * (7)</td>
<td>104500</td>
<td>44,415</td>
</tr>
</tbody>
</table>

* (1) criteria for participation in the Program
* (2) IBGE data Interpolation 2010 - households / density / preschool / income bracket in Rio de Janeiro.
* (3) After reaching the goal of SME 60,085 rooms created (2016). The population data are from 2010.
* (4) Using 1/2 minimum wage
* (5) Minha Casa, Minha Vida
* (6) No stipulates income level. 2014 data.
* (7) Used the value of two minimum wages (and not 2.5 as the Law) according to the IBGE statistics structure.

According to Vitte (2004), in the past ten years there have been changes in Brazilian administrative culture such as the development of more explicitly and more broadly defined social and economic diagnostic targets.

The establishment of places for children in child education depends on assessments that go beyond the issue of income. Among other possible criteria to define the shortage we could use: geographical conditions, infrastructure, health and mobility. An example would be the LC No111/11, Art.261, Section V which uses a framework where each age group has a specific target radius and maximum range: for facilities targeting students aged over 15 the law requires a reach of up to 15 kilometers, for children aged between 7 and 14 it is up to five kilometers and for children up to seven years old only five hundred meters.

NEW ARCHITECTURE FOR EARLY CHILDHOOD EDUCATION SCHOOL AND COST OF COUNTERPARTY

The City Government of Rio de Janeiro has created an articulated architectural program to a special learning environment and linked it to a special building developed by RioUrbe (a public company), they are
known by the title: Spaces of Child Development- EDI (Espaço de Desenvolvimento Infantil).

A standard EDI is currently designed for approximately three hundred children and has a built area of approximately 1,700 sqm. This default dimension aims to make the operation of EDI more efficient, allowing maximization of construction cost / service and maintenance. Maintenance mainly concerns the rational use of teachers schedules and employees. The land area required for implementation varies considerably depending on their proportions, reaching more than 4,000 square meters if the building is distributed in just 1 floor.

Based on the CUB (basic building unit cost), calculated monthly by Building Syndicate-SINDUSCON, the standard unit cost for housing, reaches R$ 1,600.00 per sqm (as May 2016). Considering the various equipment used in a quality day-care, its value can easily reach the construction cost of high standard buildings, i.e., close to R $ 2,000.00 per sqm. It should be considered further that the purchase of securities and various teaching materials will be required.

Therefore, a value estimated for the construction of an EDI standard, complete, land included, can reach 4 (four) million reais.

For example, the City Hall displays, on Its website (riotransparente.rio.rj.gov.br/) values up to 2.6 million Brazilian reais spent just for the construction, i.e. the construction, not including equipment, land, and supplementary materials.
COMPENSATORY MEASURES

The law establishes counterparts to the allotment and the construction of housing units. They can occur in different forms: by the allocation of areas for public equipment or by the construction of a public facility. The counterpart to allotments projects is described, first, in the Decree “E” no. 3,800, of 20 April 1970 which “approves the supplementary regulations of the State Urban Development.”

Later was edited the Law of reference for the urban allotment, Federal Law No. 6.766, of December 19, 1979, “approves the supplementary regulations of the Urban Development Law of Guanabara State, and other measures.” This Federal law demands a counterpart whereas a subdivision takes place within any municipality land.

The Decree No 322 of March 3, 1976, which “Approves the City’s Zoning Regulation” defines, in its art. 133, the benefits to license for construction of buildings of groups with 500 or more residential units.

The Dec. No. 3.800/1970 establishes, among arts. 52 and 54, the compensatory measures for property development projects. While arts. 52 and 53 define the percentages to be reserved as public areas, Art. 54, Sections I to III, requires the donation of school in the following cases:

“Art. 54 (...) I – property division with less than one thousand (1,000) lots - free;

II - property division of 1,000 (one thousand) or more lots and less than 2,000 (two thousand) lots - a standard school with 12 standard rooms and 7 special rooms;

III - property division of 2,000 (two thousand) lots or more- a standard school with 12 standard rooms and 7 special rooms for 2,000 (two thousand) lots and a standard school more with the same characteristics for each 2,000 (two thousand) lots or fraction of this parameter that exceeds the 2,000 (two thousand) initial lots. “

Art. 133 of Decree No 322/1976 deals with the construction of residential units and mandatory donations. In this provision the legislator demonstrates the concern to guarantee educational facilities in a proportional with demand generation:

“Art. 133 (...) I - grouping of buildings with 500 (five hundred) or more residential units and less than 1,000 (one thousand) residential units: a school according to standards established by the Municipal Secretary of Education and Culture, related with the number of residential units of this grouping;

II - grouping of buildings with 1,000 (one thousand) or more residential units: a school, according to the provisions of paragraph I, one more school in patterns of the first, for each 1,000 (one thousand) residential units or fraction that exceed 1,000 (one thousand) early units;”

We could consider each housing unit with a family, so, it would be provided a school for each 500 families.
Taking into account the existence of 3.1 persons per family (3.06 according to the IBGE 2010) and the percentage of 7.1%, children aged from 0 to 6 years incomplete, we estimate the existence of approximately 110 children in the exposed context.

**FINANCIAL IMPACTS OF COUNTERPARTS**

To understand the impact of counterparts in housing projects for low-income people it is necessary to understand the amount involved in the construction of housing units of social interest. With this, the public manager and the legislator can best assess which criteria to apply whenever they act in order to allocate social costs to these endeavors.

The Accounting Council of Rio de Janeiro has presented an article entitled, “Stakeholder Costs Analysis in Housing Units Construction Related to Minha Casa Minha Vida Program (PMCMV): Study of a Real Estate Development in the metropolitan area of the state capital of Rio Grande do South (Son and Souza, 2015).”

The article took as an example a venture for a construction of 220 low-units that resulted in the table below (Fig 2-values are up-to-date using national building cost Index-May 12 2016-7,2919%):

<table>
<thead>
<tr>
<th></th>
<th>2 standard bedrooms</th>
<th>1 bedroom</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Revenue</td>
<td>R$ 13,454,404.26</td>
<td>R$ 8,014,704.93</td>
<td>R$ 21,469,109.19</td>
</tr>
<tr>
<td>Direct Taxes</td>
<td>R$ 134,544.04</td>
<td>R$ 80,147.05</td>
<td>R$ 214,691.09</td>
</tr>
<tr>
<td>Net sales Revenue</td>
<td>R$ 13,319,860.22</td>
<td>R$ 7,934,557.88</td>
<td>R$ 21,254,418.10</td>
</tr>
<tr>
<td>Cost of sold goods</td>
<td>R$ 8,147,569.74</td>
<td>R$ 4,765,722.15</td>
<td>R$ 12,913,291.89</td>
</tr>
<tr>
<td>Gross Profit</td>
<td>R$ 5,172,290.48</td>
<td>R$ 3,168,835.73</td>
<td>R$ 8,341,126.21</td>
</tr>
<tr>
<td>Administrative Expenses</td>
<td>R$ 1,416,253.08</td>
<td>R$ 965,627.10</td>
<td>R$ 2,381,880.18</td>
</tr>
<tr>
<td>Selling Expenses</td>
<td>R$ 692,901.82</td>
<td>R$ 412,757.30</td>
<td>R$ 1,105,659.12</td>
</tr>
<tr>
<td>Operating Income</td>
<td>R$ 3,063,135.58</td>
<td>R$ 1,790,451.33</td>
<td>R$ 4,853,586.91</td>
</tr>
<tr>
<td>% Operating Income</td>
<td>22.77%</td>
<td>22.34%</td>
<td>22.61%</td>
</tr>
</tbody>
</table>

Fig 2- Table 2- Operational result in low-cost residences - Council of accounting.

In this example we will assume (based on an existing proposal) a situation where the legislator, with the aim of alleviating the shortage of EDI, wish to impose a counterpart for construction of 200 housing units instead of the current 500 units. Whereas the previous sheet was 220 units, for 200 units it would be a total value of 200/220xR$5,150.000= R$ 4,412,431. It is worth emphasizing the fact the TCU (Court of National Auditors) recommend the use of percentages to 7% in public construction works, contrasting with the value of 22% in cited example.

To relate the operational result of the construction of 200 popular housing with the construction cost of EDI it is introduced the following calculations:
- Profit: R$ 4,412,431
- Cost of standard EDI: R$4.0 mi (four million reais).
- Up dated Profit result: R$0.412 mi (four hundred thousand reais).
- The expected profit would be reduced from 22.61% to 3.06%.

**CURRENT COMPENSATION POLICIES**

The Government has acted to promote the expansion of the number of housing units aiming to fill this gap in the city of Rio de Janeiro, even at the expense of educational buildings generation. Complementary Law no. 97 of July 10, 2009, that “establishes rules for the edifications and groupings of edifications applicable to enterprises of social interest linked to housing policy municipal, state and federal”, reduces demands on counterpart defined in Decree No 322, arts. 133 and 134. Let’s see what is presented in the LC (Complementary Law) No 97/2009 in its Art. 6:

“Art. 6 (...) I - projects for population with lower or equal monthly income up to four times the minimum wage, are exempt;

I-........

II - housing projects intended for population with income above four and up to six times the minimum wages, half a per cent of the total cost of the enterprise;

III - housing projects intended for population with income above 6 and up to ten times the minimum wages, one per cent of the total cost of the project.”

The incentive to housing units’ increment, mainly in areas already equipped with the infrastructure, represents an actual concern whose actions are focused on various law projects under discussion at City Hall this year 2016. Legislators have preferred to impose counterparts by percentage of the projects which ensures the costs are not an impeditive.

The Decree no. 39.777, of 20 February 2015, that “regulates the conversion in cash of consignments subject to donation”, in its art. 1 establishes:

“Art. 1. The obligation to transfer free of charge to the Municipality of lot destined to the public Community urban equipment for the licensing of buildings may be fulfilled in cash when there is sufficient public equipment in certain areas or regions of the city.”

The surmounted decree allows the Public Power used the resources in a discretionary manner about the location of Community public equipment.

The RioUrbe, whose area of activity includes the management of public works infrastructure, urbanization, projects of architecture of public buildings, among other functions, suggests the cash contributions to occur in proportion to the number of units, and thus reaching a larger number of enterprises
although causing lower impacts to those who want to invest in housing construction.

**FINAL CONSIDERATIONS**

The conceptions of Stakeholders have been improved within the corporative level. This approach can be used as an important tool in the government actions, which may include, laws, programs, policies, and others actions.

It was found that one of the tools to diagnose the stakeholders are the evaluation of yields and costs. The thresholds applied for nowadays legal devices are, apparently, delimited by random values or those which do not match the actual needs of the assisted. The research included the evaluation of programs such as Minha Casa Minha Vida, the FIES (Student Financing Fund), among others relevant policies.

It was studied in more depth, as a concrete case, the case of compensation under real estate, oriented toward improvement of child education infrastructure.

This article has addressed some existing standards drawn up since the decade of 1970, whose subject focus on compensatory measures to be provided by private initiative when implementing fragmentation and construction of residential units. The cited standards set up differentiated burden according to the size of the estate ventures and impact positively on society (by the generation of a greater number of school equipment) and impact negatively on the business of the private sector. The balance between the entrepreneur’s profit and his burden may be weighted better from values involved within compensatory measures, which means to understand the of venture volume resources generated and the value of the objects under consideration, whenever they are areas of donation or educational equipment. This means to understand this kind of stakeholder.

Educational equipment in Rio de Janeiro City has been characterized by having a large structure and high constructive quality on today’s educational standards. They became high-cost structures, being able to cover an educational system that integrates early childhood education more fully and to use the educational staff of city government in a more concentrated and efficient way.

In recent years, the State has understood that housing shortage is a problem which must be dealt in synergy with private sector, resulting, as an example, the Program Minha Casa Minha Vida. Even more, it has been published laws that reduce building requirements even at the expense of the counterparts in public facilities in order to motivate the generation of greater low-income housing.

This article has sought to address several methodologies that aim to establish criteria for defining and understanding stakeholders in child education. The search for goals more consistent and guided to population’s real need has been a characteristic present in the new Public Administration. It is necessary for a greater efficiency in the application of resources, the establishment of the target public, and the production of good laws.
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Owners’ Entitlement to Receive a Defect Free Facility: What to Do?

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ABSTRACT

Purpose of this paper

Uncertainty often prevails with regards to the assessment of damages of defective work that entitles a building owner to have the work rectified/replaced and/or claim damages against the contractor in contract and/or at common law. This paper deals with the three identified periods within which a defective work claim may be made, namely: a) defects identified prior to practical completion; b) defects identified during the defects liability period; and c) defects identified after the final completion certificate is issued.

Design/methodology/approach

With the above three identified periods within which a defective work claim may be made in mind, this paper is structured chronologically in the order these periods occur during the execution of the works in order to address the rights and obligations of the parties who have in common the ultimate aim to receive/deliver a project free of any defects. Most standard form construction contracts contain express provisions that describe the process by which the contractor can be directed to rectify defective work and these will be dealt with in this paper. The approach followed was that of a desk-top study.

Findings and value

The systems, tools and techniques are available for an industry willing to embrace good practice in order to improve industry performance and project outcomes. Vigilance on the part of the principal agent/engineer is required to avoid later arguments as built environment professionals often fail to enforce the contractual requirements thereby leaving the building owner with no other option but to instigate a claim for damages for breach of contract by the contractor.

Originality/value of paper

The construction industry’s contracts etc. differ markedly from those generally used in the commercial
environment as such contracts are negotiated at industry level through an inclusive consultative process with various industry stakeholders involved and is designed to reflect current industry norms and practices.

The value of this paper is to make the reader aware of the express and/or implied provisions in the contract on how to deal with defective work claims in order to prevent disputes that translate to a high cost and time consuming process when instigating/defending a defective work claim.

Keywords: completion stages, construction industry, construction contracts, defects, standards, supervision.

1. INTRODUCTION

1.1. General

Procurement is the process which creates, manages and fulfils contracts relating to the provision of goods, services and construction works or disposals, or any combination thereof. Watermeyer (2012) observes that procurement is a key process in the delivery and maintenance of construction works as organisations invariably require goods and services from other organisations to satisfy their needs.

There is seldom the direct acquisition of construction works as client needs vary considerably. Professional services are required, as necessary, to plan, budget, conduct condition assessments of existing works, scope requirements in response to the owner or operator's brief, propose solutions, evaluate alternative solutions, develop the design for the selected solution, produce production information enabling construction and confirm that design intent is met during construction (Maritz and Putlitz, 2014).

How does one establish that the contractor has met the design intent? Uff (2009: 394) explains that where materials or workmanship are matters for the opinion of the architect (or engineer/project manager – author’s insertion), they are to be to his reasonable satisfaction. To the extent that no standards are prescribed, materials or workmanship are to be to a standard appropriate to the works.

Therefore, for the design intent to be met the works must be handed over by the contractor to the building owner free of defects. Defects in construction projects are a persistently worrying problem despite continually improving technology and education. Quality of construction is determined by the management and operative capabilities of the contractor, and by the supervisory capabilities provided by the designer with regard to the standards required. The amount of supervision required depends on the nature of the works. The building of a house may require visits every two weeks; while engineering operations may require constant attention from a resident staff according to Uff (2009: 303).

A study by Howell (1991) cited in Klingenberg and Wium (2014) about aspects of general conditions in contracts which give rise to disputes found that procurement documents need to conform to the following requirements to reduce risks inherent to construction projects:

- Clear and unambiguous explanation of the Employer’s intent;
• The intent of the contract must maintain an equitable balance between the Employer’s and Contractor’s interests; and
• Clear and complete information about:
  ◊ Scope and quality of the works
  ◊ Information on cost-affecting factors such as subsoil conditions
  ◊ Risk allocation
  ◊ Programme requirements with cost implications
  ◊ Restrictions on normal construction procedures
  ◊ Basis for interim payments.

What can be drawn from the abovementioned requirements are that procurement documents should provide clear conditions explaining obligations, roles and responsibilities and payment conditions to keep risks to a minimum. In addition to providing clarity, the contract must divide the risks equitably between the contractor and the employer. The risk allocation must be balanced with the aim of keeping the contract fair. A fair contract promotes a successful project (Klingenberg and Wium, 2014).

Notwithstanding the foregoing construction contracts are breached by both the contractor and employer on many contracts in innumerable ways and contractual remedies are then to be applied against the defaulting party to deal with the failure of that party to meet his obligations. For instance, where there are defects in the contract works, i.e. where the works itself, or the materials used, or the workmanship is not in accordance with the contract the employer may claim damages from the contractor.

Finsen (2005: 77) mentions that the contractor’s first and most obvious obligation is to carry out the agreed works and to do so with satisfactory materials and workmanship and that it is implied by law that the works will be free from defects. The contractor is deemed to be an expert of building, and is expected to ensure that the materials that he acquires for the works are not defective and that it will be fit for their purpose. Doyle (2005) confirms that it is generally accepted that a contractor will be in immediate technical breach of contract whenever works fail to comply with contractual descriptions or requirements. Wallace (1995) as cited by Doyle states this position as follows:

On grounds of both principal and practicality, a contractor will be in immediate breach of contract whenever his work fails to comply with the contract descriptions or requirements, although no doubt, as envisaged by Lord Diplock, the damages will be at best nominal in a case where he can show that he intends to rectify at some more convenient time before completion without affecting the quality of the remaining work

Ramsden (2014: 105) points out that in the case of defects the employer’s measure of damages would prima facie be the cost of remedying the defects so as to conform to the contract, but that this ‘general rule’ may be departed from if the cost of remedying the defect is disproportionate to the end to be attained, in which event resort must be had to the difference between the value of the structure as it stands as against its value in terms of the contract.
Finsen (2005: 78) refers to the fact that it is often very difficult to define the quality for producing a satisfactory standard of workmanship. In this regard the standards applied by different consultants when supervising the works may differ. However, in the absence of a contractual stipulation, the common-law position would be that the contractor has undertaken to produce workmanship that is of a similar standard to that produced by other competent contractors working in similar circumstances.

1.2. Standard Forms of Construction Contracts

Standard forms of construction contracts all include a period of time within which defects in the contractor’s work must be put right by the contractor. Standard forms of contract are popular amongst both project owners and industry because their use helps reduce procurement and contract administration costs and they are generally well understood by users, thereby resulting in fewer disputes on matters of interpretation. The purpose of standard forms of contract is therefore to facilitate the contractual arrangements between parties in a project and seek to regulate the relationships between the contracting parties, particularly in respect of risk, management and responsibility for design and execution. Standard forms of contract are ready-made terms and conditions when making a contract. These standards are commonplace in construction transactions and generally accepted by the different contracting parties. It would, however, be practically impossible to devise a standard form of contract that would account of all eventualities that might occur in a construction project as there are several factors that affect what type of contract is suitable for a certain project, e.g. the amount of involvement from the client, technical complexity, the location and size of the project. In the initial stage of the design phase, the client has to adopt a suitable contractual arrangement for the project and a corresponding standard form of contract (Maritz and Putlitz, 2014).

The advantage of using standard forms of contract may, however, be impaired when amendments and supplementary or ‘special’ conditions are included that significantly alter the standard general conditions, as there is a complex interaction between many of the terms (Ndekurgi & Rycroft, 2009). The Latham Report recommended the use of standard contracts without amendments (Latham, 1994) and amendments to standard forms were also criticized by Lloyd QC in Royal Brompton Hospital National Health Service Trust v. Hammond and Others:

*A standard form is supposed to be just that. It loses its value if those using it or, at tender stage those intending to use it, have to look outside it for deviations from the standard*.

Most conditions of construction contracts incorporate a set of conditions whose primary purpose is to set out fair, equitable, efficient, economic and transparent contract administrative procedures and allocation of risks. There is no rule to what should be included in conditions of contract, but according to Uff (2009: 277) most sets of conditions follow a standard pattern. Typically, conditions deal with:

- General obligations to perform the works;
- Provisions for instructions, including variations;

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• Valuation and payment;
• Liabilities and insurances;
• Provisions for quality and inspections;
• Completion, delay and extension of time;
• Role and powers of the certifier or project manager; and
• Disputes.

This paper will hereinafter look more closely to the express provisions with regards to quality, completion, identification of defective work and assessment of cost for remedial work as provided for in the well-used local contracts in South Africa, namely the JBCC® Edition 6.1, March 2014 (JBCC® 2014) and the General Conditions of Contract for Construction Works 3rd Edition (GCC 2015) contracts under the period headings of a) prior to practical completion; b) during the defects liability period; and c) after the issuance of the final completion certificate.

1.2.1. Overview of the JBCC® 2014

The suite of construction contract documentation prepared under the auspices of the JBCC released the First Edition in 1991 and the latest edition in March 2014 as the Sixth Edition. The JBCC concentrates on the compilation of current contract documentation with an equitable distribution of contractual risk in the building industry. The contract documentation is approved by the Construction Industry Development Board (CIDB) and used extensively in both the public and private sectors across the South African construction industry. The primary documentation is supported by a set of standard forms that should significantly simplify the administration of the contract.

The procedures described in the JBCC agreements to achieve each of the completion stages must be applied strictly to minimise disagreements later. Other than payment, completion is the most important aspect of the agreement and therefore care should be taken in certifying any of the degrees of completion. The JBCC completion stages are illustrated in Figure 1.
Figure 1: JBCC Construction and Defects Liability Timeline (Source: Guide to Completion, Valuation, Certification and Payment: JBCC Edition 6.1, March 2014 – adapted)
1.2.2. Overview of the GCC 2015

SAICE had for several decades developed, published and maintained conditions of contract for civil engineering works. Several editions of the General Conditions of Contract for Civil Engineering Works were published by SAICE culminating in a sixth edition published in 1990. The sixth edition General Conditions of Contract for Civil Engineering Works standard form construction contract was replaced in 2004 with the General Conditions of Contract for Construction Works, First Edition, “... to satisfy the CIDB’s requirements for standard conditions of contract ...”

After six years of application primarily in civil engineering works the GCC First Edition 2004 was replaced with the GCC Second Edition 2010 which fundamentally revised the First Edition: “… to clear up responsibilities and to provide for wider spectrum of construction works”. In this regard the GCC 2010 is suitable for both construction and building works contracts and although its focal point is on the contracting strategy of design by the employer, it is also suitable for the design and built contracting strategy. Thus in addition to the traditional civil engineering construction work, it is also appropriate for mechanical and electrical work as well as building work.

However, after five years of application, it became clear that certain amendments were necessary and the GCC Third Edition 2015 was prepared. Some of the most important amendments in this edition are:

- It permits the Contractor to suspend the Works if the Employer fails to make payment on a payment certificate;
- It recognises the Contractor’s time risk allowances;
- It includes delay and cost due to excepted risks, like strikes and electricity outages, as an entitlement that the Contractor may claim extension of time and additional compensation for;
- It adds a Variable Construction Guarantee to the list of securities;
- It allows for the selection of inflation indices that are appropriate to the type of Works; and
- It replaced Engineer with Employer’s Agent throughout the document because of the wider application of the contract.

2. DEFECTS LIABILITY PRIOR TO PRACTICAL COMPLETION

2.1. JBCC® 2014

Practical completion is defined as:

The stage of completion as certified by the principal agent where the works or a section thereof has been completed free of patent defects other than minor defects identified in the list for completion and can be used for the intended purpose

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The date for practical completion is contractually the most important ‘performance date’ after which the employer may occupy the building in accordance with the pre-set timeline (see Figure 1). JBCC® 2014 places great emphasis on the standard of work required at practical completion and that the principal agent, other agents and the contractor must work ‘as a team’ to achieving this milestone date. The construction period is defined in the contract data of the tender documentation. The contractor generally requires subcontractors to complete their work before practical completion, referred to as the interim completion date (clause 18.0 in the JBCC® Nominated/Selected Subcontract Agreement). These dates must be agreed between the contractor and the subcontractors. The principal agent monitors progress; together with other agents provides regular direction to the contractor and subcontractors on the building standards and the state of completion of the works to be achieved (sub-clause 19.1.1). The contractor brings the works to completion by the due date, but before that date timeously invites the principal agent to inspect the works in accordance with the programme and the (revised) date for practical completion (sub-clause 19.2.2). Where the work does not conform to the set standard for practical completion the principal agent shall issue one comprehensive list for defects to be rectified (sub-clause 19.3.1).

Under the JBCC® 2014 the employer may have the rectification of the works carried out by another contractor and the costs incurred thereto may be recovered from the contractor if the contractor fails to rectify the defective work within the period of five working days from notification by the principal agent (clause 17.3). However, the employer must be mindful of his obligation to mitigate the contractor’s loss. The judge in Mul v. Hutton held that if the employer acted unreasonably in not giving the contractor a fair opportunity to put right the defects for which it was responsible, the employer would probably have failed to mitigate that loss. The employer is generally limited to what it would have cost the original contractor to remedy the defects had it had the opportunity (RIBA Journal, 2014: 35).

2.2 GCC 2015

Before considering the provisions for rectification of defects, it is necessary to explain the GCC completion stages, viz. practical completion, completion and final completion which is then followed by the latent defects period. For the first three stages, the Employer’s Agent must issue a certificate when the Works comply with the contractual requirements laid down for the particular stage. Each of these certificates has a consequential incentive for the Contractor and the Employer with a lurking threat if the Contractor does not deliver on time and to the required quality.

The requirements for Practical Completion are set out by the Employer in the Contract Data. Once achieved, the Employer’s Agent issues the Certificate of Practical Completion with a list of items that may stand over to be completed before the Certificate of Completion is issued. The requirement for a Certificate of Completion differs from the JBCC procedure for completion which only requires practical completion. The reason for this in GCC is that some work, which are not critical for the Employer to take occupation, for example in a roads contract the finishing of slopes, borrow pits, etc. may follow after Practical Completion. The Defects Liability Period commences from the issuing of the Certificate of Com-

3 Oksana Mul v. Hutton Construction Ltd [2014] EWHC 1797 (TCC)
pletion. As soon as practical after the expiration of the Defects Liability Period, the Employer's Agent issues the Final Approval Certificate. This is then followed by the remainder of the latent defects period.

Furthermore, it is also necessary to explain what the meaning of a defect is. A defect, for which the Contractor must pay the cost of rectification, is work that was not carried out in accordance with the Contract. Such a defect may occur because of the Contractor's deficiencies in Plant, materials, workmanship or not complying with the specifications. A patent defect, meaning a defect that can be discovered by reasonable inspection, is not a term used in GCC. A latent defect is a defect that may not become apparent until sometime after completion of the Works, but is implied to be attended to before issuing the Certificate of Completion. In GCC the latent defect period starts when the Certificate of Completion is issued and ends when the specified latent defect period expires as measured from the date of the Final Approval Certificate.

It is a requirement of clause 4.1.1 that:

“The Contractor shall - - - carry out and complete the Works and remedy any defects therein in accordance with the provisions of the Contract.”

The provisions of the Contract for completing the Works are clearly set out in clause 7.2.1:

“All Plant to be supplied shall be manufactured, all workmanship shall be carried out and all materials shall be of the respective kinds specified in the Contract and shall comply with the requirements set in the Scope of Work and in the Employer's Agent's instructions. Failing requirements or instructions, the Plant, workmanship and materials of the respective kinds shall be suitable for the purpose intended.”

The phrase “suitable for the purpose intended” implies a reasonable standard consistent with the standard of similar work. Poor workmanship, unsuitable materials or defects in the work are unacceptable.

Not correcting defective Plant, materials and work is a serious breach of Contract which, in accordance with clause 9.2.1.3.5, may result in termination of the Contract by the Employer. This drastic step should only be resorted to in the extreme case of refusal to correct a defect -- there are adequate measures that make provision for the Contractor to correct defective work. (Refer to clauses 7.6.1 to 7.6.4.)

If Plant (meaning machinery or things of all kind that become part of the Permanent Works) fails the specified testing, the Employer's Agent has the power to order the making good of such Plant within a stated time period at the cost of the Contractor. Should the Plant fail a second time, the Employer's Agent has the options of further making good, acceptance at a reduced price or rejection and replacement by acceptable Plant.

The removal of defective work shown up by routine testing does not usually present a problem as this is part of the Contractor's risks and he should make provision for such events in his programme. However, when tests have shown no failure and a defect only comes to light at a later stage, it would be advisable for the Employer's Agent to consult with the Employer and the Contractor to find an alternative accept-
able solution. For example, instead of removing a bridge because of a defect in the foundation, the bridge could be strengthened to withstand the defect.

Should the Contractor fail to fix defective Plant, materials or work within the time period stated, the Employer’s Agent may, as a last resort before terminating the Contract, employ others to fix such defective work and recover the costs from the Contractor. As such action is optional; the Employer’s Agent should carefully consider whether terminating the Contract would not be a better option. For example, termination would be a better option for a recalcitrant Contractor, whereas for a Contractor who lacks expertise, the better option would be to employ the necessary experts.

3. DEFECTS LIABILITY DURING THE DEFECTS LIABILITY PERIOD

3.1. JBCC® 2014

The defects liability period commences on the calendar day following the date of practical completion and end at midnight ninety calendar days from the date of practical completion or when the work on the list for final completion has been satisfactorily completed, whichever is the later (clause 21.1).

The principal agent shall forthwith after practical completion has been achieved issue the list for completion to the contractor. The list for completion is defined as:

A list issued by the principal agent where practical completion has been certified, listing defects and/or outstanding work to be completed.

The principal agent issues a list for completion to permit the contractor to complete all defective/outstanding work (sub-clause 19.3.4) or where defects become apparent during the defects liability period the principal agent may instruct the contractor to attend to such items (clause 21.2). For instance, should a leak or any other event occur requiring immediate attention – this must be dealt with expeditiously in terms of a contract instruction (sub-clause 17.1.11) from the principal agent to the contractor and/or subcontractor outside the list for completion. The contractor must rectify the defects on the list for completion progressively, whilst at all times minimising inconvenience to the occupants. The principal agent may only add items that have become ‘patent’ and of any further defects that have become evident since the last inspection (sub-clause 21.7.2) to the list for final completion, issued after the expiry of the defects liability period (clause 21.6). Final completion, therefore, follows a minimum of ninety calendar days after practical completion – to allow for the contractor to rectify all items on the list for completion and for the identification and rectification of latent defects not in evidence at practical completion and for working of items on the list for final completion.

Final completion is defined as:

The stage of completion of the works as certified by the principal agent as being free of defects.

The definition of final completion requires the principal agent to certify “... the stage of completion of the
works to be free of defects..." The issued certificate of final completion is "...conclusive as to the sufficiency of the works and that the contractor's obligations have been fulfilled other than for latent defects" (clause 21.12). A careless signature by the principal agent may result in a claim for professional negligence by the employer and according to Finsen (2005: 137, 138) there is no further recourse for the employer to bring a defective work claim as the final certificate, once issued, cannot be withdrawn or amended.

3.2. GCC 2014

The Defects Liability Period starts when the Certificate of Completion is issued and lasts for the period stated in the Contract Data; usually 12 months for construction works. According to clause 7.8.1 the intention is that the Permanent Works must be in the condition required by the Contract at the expiration of the Defects Liability Period. During the Defects Liability Period, if a defect becomes apparent, the Employer's Agent must order the Contractor to make good the defect. This will not only include defects attributable to the fault or failure of performance by the Contractor (to be repaired at his cost) but also defects caused by other causes. These other causes do not include “fair wear and tear” meaning the deterioration due to the occupation or use of the Works by the Employer. Should a damage where the Contractor is not at fault, for instance damage due to vandalism, need to be repaired, the Employer will have to pay for such repairs as it must be valued by the Employer’s Agent in the same way as for a Variation Order.

The Defects Liability Period may be extended by an order in writing, given during the Defects Liability Period, by the Employer’s Agent in respect of the following:

- Outstanding work specified in the Certificate of Completion in accordance with clause 5.14.4 and not completed within the allowed time.
- Searching for a defect in terms of clause 7.7.1.
- Clause 7.8.1 stipulates that if the making good of defects, as ordered in writing by the Engineer, is delayed by the Contractor’s own fault, the Defects Liability Period will be extended by the additional time taken by the Contractor to effect completion of the outstanding work.

Should the Contractor fail, within 28 days of receipt of written notice from the Employer’s Agent to do any remedial work, clause 7.8.3 allows the Employer to have such work done by others and recover the cost from the Contractor.

Closely linked to the Defects Liability Period is retention money. Clause 6.10.3 allows the Employer to retain, for the duration of the Defects Liability Period, a stated portion of the amounts of money due to the Contractor. This retention money serves as a security for the Employer, should defects that must be made good, become apparent during this period. It is also an incentive for the Contractor to attend diligently to the repair of defects because it will be paid back to the Contractor within 14 days of the end of the Defects Liability Period except that for defects, not repaired yet, the Employer may withhold so much of the retention money as representing the cost of such defects (clause 6.10.5.1).

4. DEFECTS LIABILITY AFTER THE ISSUANCE OF THE FINAL COMPLETION CERTIFICATE

4.1. JBCC® 2014

As stated under 3.1 above a certificate of final completion issued by the principal agent shall be conclusive as to the sufficiency of the works and that the contractor's obligations to bring the works to practical completion and to final completion have been fulfilled other than for latent defects (sub-clause 12.2.17 and clause 21.12)

In common law the liability of the contractor to the employer for latent defects is open-ended and will only expire with the demolition of the building – clearly an untenable situation. In the JBCC® 2014 agreement (clause 22.1) the latent defects liability period for the works is restricted and shall commence at the start of the construction period and end five years from the certified date of final completion as illustrated in Figure 1. Finsen (2005: 139) confirms that this limitation of liability varies the common-law position in which the contractor would remain liable for latent defects for all time – or at least, until the building is demolished.

Latent defects are defects that could not be identified during normal inspections and which will manifest after the final completion certificate has been issued (excluding normal wear and tear) and are dealt with during the latent defects liability period. The contractor shall make good all latent defects that appear up to the date of expiry of the latent defects liability period (clause 22.3) as the issuance of a final completion certificate under a building and construction contract does not terminate the contractor's obligation for damages arising out of defective work claims (Doyle, 2005).

4.2. GCC 2015

It is the nature of construction projects that faults and defects caused by failure in design, workmanship or materials may only become apparent many years after completion and it is not always evident whether it is caused by a design, workmanship or materials defect. These defects are known as latent defects. A typical example is misplaced reinforcement in concrete which will take time to show visible defects but eventually will damage the structure. In GCC the duration of the latent defect period is the choice of the Employer who must state it in the Contract Data. For civil works it is usually ten years; for buildings it is usually five years; for mechanical and electrical works it is usually three years. Prescription, as laid down by the Prescription Act 68 of 1969 as amended, allows the Employer a period of three years from the date that the defect due to the Contractor's fault was discovered, to enforce his right to have the defect remedied by the Contractor.

The major problem with latent defects is the consequential damage and liabilities that can follow on failure of a structure due to a latent defect. Typical examples are the premises that burnt down because of a latent defect in the electrical installation, the falling down of a concrete structure, killing people, due to a latent defect, etc. Insurers will rarely cover the defective part itself resulting from a defective design, workmanship or materials. However, a professional indemnity insurance policy for a designer and product guarantee/liability insurance covers for a contractor could cover the consequential damage/liability of a latent defect. Should the Employer require such insurance, an insurance broker should be consulted...
and the requirements set out in accordance with Clause 8.6.1.5 in the Contract Data.

5. ASSESSMENT OF DAMAGES UNDER A DEFECTIVE WORK CLAIM

The purpose of damages for breach of contract is to compensate the owner for the loss which has been suffered if the contractor does construction work defectively. The central question is how to measure this loss. A defective work expense and/or loss claim is usually for the cost or estimated cost of rectification of the defective work. Sometimes, instead of the cost of rectification the courts award the plaintiff the difference in value between the intended value of the work and the actual value of the work on account of the defective work. Furmston (2012: 246) cites a House of Lords case that endorses this statement. In that case the judge decided that, because it would be unreasonable to carry out the remedial work, the difference in value between the building as it is and as it would have been if the contract was properly performed, was to be the primary measure.

These principles governing the award of damages for breach of contract were further expanded on by Innes CJ as cited in Finsen (2005: 14) as follows:

\[\text{The agreement was not one for sale of goods or of a commodity procurable elsewhere, so that we must apply the general principles that govern the investigation of that most difficult question of fact – the assessment of compensation for breach of contract. The sufferer by such a breach should be placed in a position he would have occupied had the contract been performed, so far as can be done by the payment of money, and without undue hardship to the defaulting party.}\]

The issue of ‘without undue hardship’ is universally applied as affirmed in the United Kingdom (UK) High Court’s decision cited in Doyle (2005) as the leading authority in the UK on the measure of damages for defective and incomplete work. In this case the plaintiff cross-claimed against the builder for the cost of demolition and rebuilding of the house as a result of faulty construction of foundations. At paragraph 617 the court said:

\[\text{In the present case, the respondent was entitled to have a building erected upon her land in accordance with the contract and the plans and specifications which form part of it, and her damage is the loss which she has sustained by the failure of the appellant to perform his obligation to her. This loss cannot be measured by comparing the value of the building which has been erected with the value it would have borne if erected in accordance with the contract; her loss can, prima facie, be measured only by ascertaining the amount required to rectify the defects complained of and so give to her the equivalent of a building on her land which is substantially in accordance with the contract (emphasis added by Doyle).}\]

5 BK Tooling v. Scope Precision Engineering 1979 (1) SA (A)
7 Victoria Falls and Transvaal Power Co Ltd v. Consolidated Langlaagte Mines Ltd 1915 AD 1
8 Bellgrove v. Eldridge (1954) 90 CLR 613
However, the general rule was subject to two qualifications. At paragraphs 618 – 619 the court added:

We prefer, however, to think that the building owner’s right to undertake remedial works at the expense of a builder is not subject to any limit other than is found in the expression ‘necessary’ and “reasonable’ ...

Many examples may be given of remedial work, which though necessary to produce conformity would not constitute a reasonable method of dealing with the situation and in such cases the true measure of the building owner’s loss will be the diminution of value, if any, produced by the departure from the plans and specification or by the defective workmanship or materials (emphasis added by Doyle)

As to what is both ‘necessary’ and ‘reasonable’ in any particular case is a question of fact according to Doyle (2005).

6. CONTRACTOR’S RESPONSE TO A DEFECTIVE WORK CLAIM

Prudent contractors protect themselves from liability arising out of their work on a construction project by maintaining construction all risk (CAR) insurance cover. However, such a CAR policy generally does not provide coverage for claims by discontented owners for the cost to repair or replace allegedly defective work. Such claims, which can present a significant exposure to a contractor, instead are governed by the contract between the contractor and client. As a result, the terms of the warranty and indemnification language in construction contracts are hugely important and frequently misunderstood. The purpose of a warranty is to limit the contractor’s responsibilities in the event the work does not meet the owner’s expectations. Similarly, indemnification clauses can be used to shift the risk of defective work to others and to allocate the risk among multiple parties who may be responsible for the final product. It is therefore essential for contractors to understand the limitations of their liability insurance coverage, and to pay particular attention to the drafting of their contracts, seeking professional legal assistance where needed. Proper drafting on the front end can save substantial expense on the back end.

From a contractor’s perspective, defending a defective work claim can be expensive and often the nature and extent of the damage is hotly disputed, leading to a high cost and time consuming process in defending the claim. This is regardless of the timing of the making of the defective work claim by the building owner and/or the principal agent/engineer. For the sake of practicality and in preparation for a possible defective work claim Doyle (2005) put forward the following steps what he regards as in the interest of the contractor to do:

- establish the ambit of its contractual responsibility in relation to the design;
- be clear as to any express and/or implied representation made in the documentation relating to and part of the contract as to the quality of workmanship;
- be aware of any express and/or implied statements in the contract as to the purpose of the works;
- be clear as to any express, implied and/or actual reliance on the part of the owner as to any of the contractor’s obligations, skill or expertise; and
• establish a contemporaneous documentation procedure to ensure all directions, instructions, notifications, possible waivers, etc. are recorded in a timely and relevant manner.

7. CONCLUSION

Standard form construction contracts generally provide for specific procedures related to defective work claims made during the pre-determined contractual completion stages and after the issue of the final completion certificate. The entitlement to make a defective work claim after the issuance of the final completion certificate is complicated by various factors, inter alia that the contractor may no longer be in business, there is no financial hold on the contractor because of the expiration of the performance guarantee and the difficulty often to establish whether the defective work is as result of a design or specification shortcoming/oversight, normal wear and tear or caused by the contractor or his subcontractors.

7. References


Restoration public works in Brazil: The costs analysis based on Federal Decree 7983/2013

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ABSTRACT

The Brazilian Federal Decree 7.983/2013 lays down rules and criteria for the preparation of costs reference of works and engineering services, contractors and executed with federal funds, in addition to verification criteria of costs and the priority use of the National System of Costs Survey and Indexes of Construction - SINAPI, as the cost base reference. The guidelines established by the Brazilian Federal Court of Accounts - TCU, in particular the judgments 2.369/2011 and 2.622/2013, set the limits for all indirect costs - Budget Different Income – BDI. Restoration public works, executed with federal funds, must conform with the Federal Decree 7983/2013 and with the Federal Court of Accounts. How to do it if this kind of works is so particular and different from usual civil construction works? This paper intend to discuss if these requirements are possible to apply in restoration works and how to adapt this application, considering the particularities of this type of work. The proposed methodology, for analyzing the costs, includes the use of the following tools: ABC curve of services, evaluation of the BDI, criteria of the Federal Decree, use of SINAPI reference and other costs bases. It is possible that preservation institutes and designer professionals find a way to reduce distortions between different regions of the country and systematize cost compositions of restoration services. This article has the objective to disseminate the discussion about the similarities and the differences between restoration and civil construction works and to present a possible way to analyze the costs, and discuss the need to develop a cost reference to this type of public work in Brazil.

Keywords: Cost Engineering, Brazilian Cultural Heritage, Restoration Works, Cost analysis
1 INTRODUCTION

1.1 National System of Costs Survey and Indexes of Construction - SINAPI

In 1969 the Brazilian government created this database to provide information about costs and productivity in civil construction, to the National Housing Bank - BNH. The survey was first conducted for the housing sector. After the extinction of the National Housing Bank, in 1986 CAIXA, nowadays the third largest financial institution in total assets in Brazil started to use SINAPI as a standard to finance and to control housing works. The System is produced in partnership with CAIXA and with the Brazilian Institute of Geography and Statistics – IBGE, the main provider of data and information about the Country.

The SINAPI produces costs and indexes for civil construction through the data collection of prices of material and wages paid in civil construction for the housing sector. The System was expanded in 1997, when it started to include the sanitation and infrastructure sector.

It has as collection unit the suppliers of construction material and the construction companies of the sector. Information on sanitation and infrastructure only includes data relative to prices.

In 2009, CAIXA shall publish on the Internet the services and costs reference database, then becoming the main source of public consultation of the construction costs. In 2013, starts in CAIXA the process of measuring the compositions of SINAPI database.

1.2 Federal Decree 7.983/2013

In 2003, the Budget Guidelines Law defined the SINAPI as price limit for services contracted with funds from the Federal Budget. In 2013 the theme was removed from the Budget Guidelines Law and was treated by Federal Decree 7983/2013.

This Federal Decree lays down rules and criteria for the preparation of costs reference of works and engineering services, contractors and executed with federal funds, in addition to verification criteria of costs and the priority use of the National System of Costs Survey and Indexes of Construction - SINAPI, as the cost base reference. SINAPI became the benchmark cost for construction and engineering services, including restoration works contracted with federal funds.

1.3 Brazilian Federal Court of Accounts - TCU

The Brazilian Federal Court of Accounts – TCU audits the accounts of administrators and other persons responsible for federal public funds, assets, and other moneys, as well as the accounts of any person that causes loss, misapplication, or other irregularities that result in damages to the Brazilian public treasury. The main concern of the Brazilian Federal Court of Accounts is the incessant fight against corruption, waste, and the misuse of federal resources.

Therefore, besides carrying out audits that are directed by Congress or originated by denunciations or petitions, twice a year the Court establishes a schedule of audits to verify the correct use of public funds.
by the organizations and entities under its jurisdiction.

Such inspections are called compliance audits. Worthy of note are, as an example, audits carried out to scrutinize public works that have received federal funds in order to report their status to Congress. This allows members of Congress to form an opinion as to the convenience or not, of disbursing budgetary funds for the maintenance or for resuming the works.

The Brazilian Federal Court of Accounts – TCU conducts studies that support the establishment of standards to assess the costs of public works. Among these studies, some resulted in judgments 2622/2011 and 2369/2013, which set the limits for all indirect costs - Budget Different Income – BDI rate, or Indirect Expenses and Bonification. This rate for the construction industry is the sum of all indirect expenses necessary for the administration of the work, including the builder profit.

1.4 Growth Acceleration Program for Historical Cities - PAC CH

The Growth Acceleration Program (PAC), launched in 2007, is an initiative of the federal government coordinated by the Ministry of Planning, which promoted the resumption of the planning and execution of great works of social infrastructure, urban, logistics and energy of the country.

In 2011, the Program has entered its second phase with more resources and more partnerships with states and municipalities.

In 2013, the Ministry of Planning authorized the creation of a line dedicated exclusively to urban historical sites protected by the Institute of National Historical and Artistic Heritage - Iphan, giving rise to the Growth Acceleration Program for Historical Cities - PAC CH.

In cooperation with several co-performers, especially universities, other federal institutions for technical support, states and municipalities, the Institute is implementing the program in 44 cities in 20 states. Investment in restoration work is $ 1.6 billion for the 425 restoration works of buildings and public spaces.

2 SIMILARITIES AND DIFFERENCES BETWEEN RESTORATION WORKS AND COMMON CONSTRUCTION WORKS

The first difference between the restoration works and construction works begins with the historical aspects that characterize the constructive production of both. In restoration works, doesn't matter if the edifices or spaces are from the past and still exist.

The decision involves factors to establish what preserve and why. No matter the age of the object, but the importance and the historical context in which it is inserted. It is important the recognition by the preservation organs, and the exceptional nature of isolated work or of the set.

The common building works have not anachronistic construction processes. Those building works are perfectly adjusted to the production of the construction market. Even considering the forefront projects that propose new solutions have in their favor the research and the necessary tests. Not the case to deep-
en the issues of selection of what preserve, because the subject is extensive, and involves theoretical studies.

One similarity between contemporary civil work or new construction work, and the restoration works, is that both should be well-designed, with designs that provide all data necessary for the preparation of costs and physical-financial schedule.

It is necessary to consider that the object is already built, and that was also built with the choice of the party from the basic needs program in a program defined by the authorized representative of the epoch. Considering the current times what more would approach are the works of reform. Changes are not usual changes in restoration work due to unforeseen discoveries during surveys and mapping damage (Lemos, 1989).

The archeology requirements must be monitored, especially when there are traces of constructive order or even historical events that must be investigated, also considering the opportunity of the event. Any necessity opening ditch, to pass piping or structural repairs, and consolidation works must be accompanied by experts, and therefore should be part of the budget and schedule of work.

Therefore, restoration works, as well as contemporary works of reform, may present unforeseen, because of pre-existing elements. It is not always possible to perform all the necessary surveys before the start of the work, either by difficulties in hiring or by the degraded state of conservation that does not allow access to some elements of the building for example. It is necessary to create safe conditions for such a situation.

In both cases, design changes, or paradigms may occur, but it must be considered that the decision making in the case of restoration involves exchange of information between experts, involves prior approval of the conservation body that monitors and oversees, what always demands time, more than common works.

Restoration works of edifices have a big variety of shapes and styles that will get closer or distant to contemporary techniques. The most complex examples can be seen in religious architecture, which is the most representative collection of colonial period in Brazil, with influence of European styles of the time, Dutch, French or Portuguese - mostly. Some of them are buildings from the sixteenth and seventeenth centuries, permeated by changes or adjustments, often in the eighteenth and nineteenth centuries, according to Oliveira (2015).

In this context, some parts of the building have artistic details that are integrated in facades and inside, making the rich collection of style - baroque, rococo, mannerist, neoclassical and more recent. This part of the adornments that are integrated to the walls, the door jambs and windows, is eminently artistic character and require skilled and specific labor for its restoration. Masonry walls include frescoes, “escaïolas” (marbling), or application of specially made tiles for that building, beyond good integrated wood carved and painted.

In this context, contemporary works that are exceptional, in terms of architectural design, may also con-
template details and specialties that will also require materials, and labor work, nonstandard, though supported by the industry of civil construction and others. Restoration works must have restorers and craftsmen trained in specialized schools.

The application of traditional building techniques is important when dealing the conservation of the built cultural heritage, and the professional who brings together the skills for such services are the craftsmen.

To understand the practice of traditional building techniques, according to Tinoco (2012), it is important to know the meaning of tradition. This term is used to describe the transmission of customs and practices through oral narratives, when habits, values and knowledge are passed from generation to generation. The construction technique term corresponds to the procedures of the art to build. It refers to the rational processes and the practical procedures for the use of natural materials, manufactured and processed to meet human needs. In the context of cultural heritage, traditional construction techniques are the processes and operating procedures of building materials, transmitted by past customs and practices from generation to generation, from father to son.

Differently of restoration works that demand special hand works, civil construction works have great offer of hand work. In the past this great offer was because of low school and professional education, with services with little or no technological incorporation. Cardoso (2009) mentions that currently the civil construction has increased the prefabrication supplies, with the use of prefabricated structures, like sealing wall using the drywall, coatings of prefabricated facades, and the degree of combined services, when suppliers of material began to offer the material with the bound service, for example, steel-ready and, most recently, ready masonry (suppliers blocks) and ready facade (providers ceramic coating).

The hand labor of civil construction is better organized in appropriate associations to defend their labor rights, such as trade unions. The bargaining power, including the use of the right to strike, is large and directly influences the costs of construction, where about 50% of the cost in the composition of a service is formed by the labor costs on average.

Construction companies are also highly organized, with employers’ unions and associations with high bargaining power and influence even in National Congress, where several laws of interest to the sector are discussed. Companies in the restoration of the sector are also organized in associations such as the Restoration Companies Association - ASSEER, founded in São Paulo, in September 2011, to defend the interests of enterprises and organizations of the restoration industry.

In order to maintain the craft of artisans, in Brazil there are some institutions for local training of new specialists in restoration as the Center for Advanced Studies in Integrated Conservation - CECI in Pernambuco, which offers the course of Management and Practice of Conservation and Restoration. In Bahia, the School of the Bahia Federal University Architecture offers the course Professional Master in “Conservation and Restoration of Monuments and Historical Centers (MP- CECRE).”

But there are few institutions compared to the civil construction that has several institutions spread throughout Brazil that make labor to the market, with many technical courses and specializations. All this influenced by the fact that the labor market has more demand for construction than for restoration.
work, which, incidentally, are a timid and recent demand in terms of public policy.

Many materials and many construction techniques have not changed, however became industrialized, for example, ceramic bricks and clay tiles, which are no longer handmade, but some structural and sealing elements have changed a lot. In the past, the structures could be of stone, adobe, special stone and rammed earth (ancient technique using wooden forms, as in reinforced concrete, only with clay crumpled in pestle) for example.

According to Colin (2010), wood is the material widely used in wooden structures in half-timbered, the covers and inner sealing elements, in ceilings, artfully treated with carvings and paintings. In most of the religious buildings, the wood is largely finished off with gold leaf. The sealing walls that were more used the colonial period - masonry bricks or stones hand, aggregated with mortar of lime and clay, or only clay - were replaced by sand mortar and cement in today’s times.

In general the painting was lime for the mortar walls. There are specifications for adornments, whose materials are found only in specialized art shops, as gold leaf. The assembly of the worksite, for restoration works, demands conditions similar to new works, like its components.

However, because it is an edifice or place already built, often in precarious conservation status, bordering on ruin, with fragile elements whose damage during the work could not be repaired, the worksite for restoration work requires more elaborate organization, sometimes with mounting restrictively site, and internally with the need to protect floors and decorative elements.

For the integrated goods, carved wood, as liners and altars, with termite attack, it is necessary to disassemble and work on surfaces like countertops inside the building, for their recovery and replacement.

Restorations of chattels, and imaginary and furniture, such as chests, credenzas, tables and others may receive treatment on site, depending on the situation, but sometimes the removal is impossible.

The frame restoration of a painting, the restoration of a wood ceiling, and the furniture restoration can demand special spaces in the worksite, especially if this wood ceiling is an artistic painting.

This requires space and studio assembly, with appropriate lighting, and special care in the generation of dust, the transit of people, the generation of noise, because these are services requiring concentration and care, as shown on photograph 1 (frame restoration - Painting) and photograph 2 (Table restoration - strengthening the chassis and gilding with gold leaf).
Photograph 1 Example of restoration service - Painting.
Author: Marco Aurélio da Silva Máximo

Photograph 2 Example of restoration service – Frame painting.
Author: Marco Aurélio da Silva Máximo
There are many special tools developed and used in restoration works: surgical scalpel, and stainless steel tweezers. Some unusual materials in the common construction and widely used in restoration services are: acetone, oxalic acid, cotton wool, Armenian cake, gold leaf, rabbit glue, dental plaster, isoparaffin, micro glass ball, bamboo toothpick, Japanese paper, tracing paper, agate pot, permethrin and various pigments, for example.

Many common services in restoration are not found in cost bases usually used in works of common construction.

Many elements of stone, marble, used in pillars, floors and decoration are not found as input of service compositions in the costs basis.

Restoration of portuguese tiles and special pavings, as the so-called feet-of-tomboy and others are also special, and there is not in the cost base SINAPI any similar services that can be used. The replacement materials can even be extremely difficult to achieve, by the difficulty of finding materials in the same specifications and conditions, requiring replacements that have to be approved by Heritage organs. Some examples of special materials and special structures are in photograph 3 and photograph 4.

Photograph 3 Example of restoration service – Portuguese tiles.
Author: Marco Aurélio da Silva Máximo
3 METHODOLOGY AND RESULTS

3.1 Sampling selection for the methodology application

In general it is not feasible conduct research and studies in all the population or universe of interest. So, the solution is to get a representative sample of that universe, so the results can be generalized for the population. When the population is made up of sub-groups or strata, it is reasonable to assume that the variable of interest has different behavior in different strata, we are dealing with a stratified random sampling. Therefore, so that the sample is representative, it must have the same stratification of the universe that is being studied (Callegari-Jacques, 2003).

Due to the constructive and architectural features quite varied, it is possible to assume that the alignment and approach of the services of the budgets of restoration works with SINAPI has varied behavior according to the type of architecture. The definition of the type of buildings and monuments that were the subject of application of the proposed methodology took as a basis the list of actions of the PAC Historical Cities Program, established in Ordinance number 383/2013 - Iphan, published in the Official Gazette and on the site of the institute (IPHAN, 2013).

Of the 344 remaining shares, 18% are of restoration of buildings of the official architecture (Chamber houses and jail, palaces, town halls and fortifications), 52% of civil architecture buildings (houses) and 30% of examples of religious architecture (convents, monasteries, Jesuit sets, churches and chapels). The Growth Acceleration Program for Historical Cities - PAC CH is running, with shares in several stages, many of them in project preparation, with other works in progress and some already completed.
From the projects that have available material for the study, was then established a sample of 18, ie, equivalent to 5% of the total shares related to the official, civil and religious architecture, because they represent the most commonly types of architecture of restoration works in Brazil. Applied the methodology to the costs of 3 edifices of the official architecture (1 Chamber House and Jail, 1 Fortification, 1 Hall), 8 edifices of civil architecture (4 mansions, 2 theaters, 1 Market and 1 Warehouse) and 5 edifices of the religious architecture (all churches with and without integrated goods), seeking thus to approach the same stratification between the sample and the list of PAC CH for the three aforementioned types. The values of the budgets of these restoration works ranged in magnitude from 900,000 reais to up to 14 million, totaling approximately 77 million reais the sample budgets.

3.2 ABC Curve of services

According to Cardoso (2009), in general the budgets in engineering works has a large number of items, which prevents complete verification of the entire cost. The analysis is done only for the items considered important. Thus, the identification of these items is critical and the appropriate tool for this identification is the ABC curve.

The origin of the ABC curve is linked to the concept established by the Italian economist Vilfredo Pareto, who in 1897 had observed in his studies on income distribution, that this distribution not occur uniformly, concluding that there was a high concentration (80%) on the hands of a small portion of the population (20%), and observed this in several countries (Ivančić, 2014).

It was established the principle called Pareto or also known as the 80/20 rule, which statistically means that for every phenomenon, about 80% of the effect is 20% of the causes, that is, most of the results in any status is determined by a small number of causes. The Pareto principle has many applications such as quality control, the risk management, audits in general, and budget analysis, among other applications.

The ABC curve is nothing but the graphical representation of the hierarchy of cost items, by affecting the cost. The curve shows that a relatively small quantity of items is responsible for a large impact on cost.

According to Meneses Filho (2014), ABC curve is an important tool to be used in the phases of budgeting and management, guiding the acquisitions and management optimization effort. It is because the curve indicates the services and supplies which should be given greater attention.

While there may be variations, generally adopts the following classification: The items in the range A (top) covers the items that together represent 50% of the total cost of the work; items in the range B (intermediate) include items between 50% and 80% on the percentage scale of the accumulated cost, thus representing 30% of the total cost; and finally the range C (base) contemplating the rest of the items. In general, the range A has fewer items than the range B, and B less than the range C, so the ranges A and B together account for 80% of the total cost of the work.

3.3 Requirements of the Federal Decree 7.983/2013

The Federal Decree 7.983 / 2013 establishes rules and criteria to be followed by agencies and entities of
the federal public administration for the preparation of reference works and engineering services cost, contractors and executed with the Union cost resources. Its purpose is to standardize the methodology for the establishment of the reference cost and establish parameters to control the use of federal funds (Decreto Federal 7.983, 2013).

Another intention of the decree is to gain greater control of spending and ensure greater advantage, efficiency and quality in contracting works and engineering services. For this must obtain all the necessary elements arising from the preparation of basic and executive projects, descriptive memorials, specifications and all other essential documents for the perfect understanding and quantitative calculations required for the preparation of the cost. In the wake of legal responsibilities, the budget that will be included in the bidding documents shall be prepared and signed by a qualified professional with an indication of their technical responsibility record. The reference budget is a breakdown of the global reference price expressing the description, quantities and unit costs of all services, including their unit costs compositions necessary to perform the work and compatible with the design that integrates the bidding.

In preparing the cost, the decree also establishes the reference base to be employed, and this cost base is the National System of Costs Survey and Indexes of Construction - SINAPI. However, the decree opens the possibility of obtaining other reference values, and allows forming other specific compositions. In the case of restoration works, it is often necessary to develop their own compositions using SINAPI price indices for inputs and labor rates from other sources, for example. Only after exhausting the previous possibilities is that the market prices may be used, following rule specifies of minimum of three quotations.

Another important aspect of the decree is the establishment of elements of Indirect Expenses and Bonification - BDI applied to the cost resulting in the overall price of the worksheet, being aligned with the Brazilian Federal Court of Accounts - TCU, in particular the judgments 2369/2011 and 2622/2013, and to apply these judgements, restoration works should be considered as reform. Also regarding the BDI should highlight the need for development and application of a reduced and differentiated rate for equipment and specific materials. To carry out the transfer of funds, the holder body of resources must use the reference budget, and other technical documents, and analyze at least 10% of the relevant cost items, that correspond to a minimum of 80% value of the total value of works and engineering services, excluding the cost of services for the mobilization and demobilization, construction site and local administration, which should be fully analyzed. For this analysis, the manager is induced to use the Pareto principle to the classification of budget items by ABC curve. Thus the analysis accurately should prioritize the ranges A and B as they present the most relevant items to check specifications, quantity and unit costs compositions, especially when they result in own compositions, a common situation in the restoration works. Items with “overpricing” are evidenced, thus facilitating further analysis.

3.4 Considerations about the National System of Costs Survey and Indexes of Construction - SINAPI

The preparation of the compositions SINAPI consists of a complex process, which means the establishment of productivities, equipment and material consumption involved in the execution of certain task or service. The IBGE collects field data, measuring in several construction sites of the country, observing similar services in public and private works, in small and big works. Data collection has a volume designed
to measure and extract average rates of productivity and consumption of raw materials and design of the use of equipment, it is generally measured at least ten different works with daily measurements for at least 5 days each, aiming represent in the most appropriate way the reality of Brazilian works, standardizing the technical criteria adopted in the design of the references. These studies are already established and are constantly measured, including price surveys carried out each month on the market in several capitals of Brazil. For labor, productivity is extracted by the relationship between the effort (hours worked and idle) with the amount produced of the service. In the case of materials are considered the theoretical and real quantity, the first without the inefficiency or waste production, and the second covering losses, which are all that is consumed more than the theoretically required. Losses are classified by their effect on the receipt of materials in storage, the intermediate processing, the end processing and internal transport. As to its nature, the losses could be in the waste and built form, in addition to losses by theft. Only the latter is not included in the compositions measured by SINAPI.

To calculate the productivity of the equipment it is necessary to consider the time needed for preparation and demobilization of the teams involved at the beginning and end of each working step, in addition to the time required for maintenance. With measurements in the field then appropriates the uptime and downtime of the equipment involved in the service. The compositions have their monthly costs assessed to ensure the updated prices for users of SINAPI.

Moreover, it is essential to know the SINAPI compositions, because in the case of them not being appropriate to the restoration works of historical heritage, the exact way they are established for common work, priority should be given to adaptation of the compositions before use other baselines or market prices, so then setting compositions called “own”, replacing inputs and / or changing their consumption rates (CAIXA ECONOMICA FEDERAL, 2014)

3.5 Requirements of the Brazilian Federal Court of Accounts - TCU

According to Cardoso (2009), all the costs happen in the construction site and are divided in direct and indirect:

- **Indirect costs**: affect all the items during the building process generically and without distinction. These costs are associated to the administrative staff, safety equipment, tools, benefits, consumables etc. They do not vary with the quantities produced or the time.

- **Direct costs**: costs that can be attributed to specific, individual items used in the construction exercise and which directly affect the costs of construction. These are usually represented by the labor and materials used in the works (e.g. pipes, cement, sand, laborers needed for laying down service network etc). These costs, are also called variable costs given that they vary according to the quantities of services measured.

Indirect cost is the sum of secondary costs to support the execution, like local administration, mobilization and demobilization, and construction site.

According to TCU (2014), cost is the sum of financial resources to production and expenses are financial resources to maintenance of a company, for example. Costs can be attributed to the final product and
expenses have a general character, difficult to link to products.

Expenses happen outside the construction site. Indirect expenses are expenses arising from business activities that focus percentage form on the costs of the work. These are resources for the payment of taxes; the apportionment of central administration costs; the remuneration to the builder by the assumption of the enterprise risks; and compensation of financial expenses caused by the mismatch between spending, measuring and receiving.

The cost of a construction work is the sum of all the costs of the goods and services needed for its production, and the price of the finished development represents all the costs including the constructor profit and indirect expenses. It is necessary to quantify the indirect expenses of administration, like central office, financing, marketing, depreciation, maintenance, taxes and insurance. To find the price of a construction it is necessary to sum the costs (direct and indirect) with indirect expenses of administration (external to the building site) and the constructor profit (Cardoso, 2009).

At the budgeting stage it is a common practice, mainly for public works in Brazil, to calculate the price by applying a charge called the BDI (Indirect Expenses and Bonification/ Premium), which normally varies from 20 to 30 percent on the direct cost. This is applied to all the indirect costs (production and administration) plus profit and results in the final price (Cardoso, 2010).

The Public Administration needs to develop a reference budget to contract a public work, and this budget is the price, or the result of application of the rate of BDI over the costs.

It is important to remind that the BDI rate developed is theoretical, because the public administration is not a company.

To calculate the BDI, the Brazilian Federal Court of Accounts - TCU established the formula (1):

$$BDI = \frac{(1 + (AC + S + R + G))(1 + DF)(1 + L)}{(1 - I)}$$

Where:

- AC – Central Administration or Central Office;
- S - Insurance;
- R - Risks;
- G - Guarantees;
- DF – Financial Expenses;
- L - Profit;
- I - Taxes (PIS, COFINS, ISS e CPRB).

The judgment of the Brazilian Federal Court of Accounts - TCU 2.369/2011 established the parameters of the plots and the final value of the BDI, to mark the contracting of public works in the country. On that
occasion brought in detail the limits for building works with reform, in addition for hiring infrastructure works.

In this occasion the criteria was focusing in the values of the budget, establishing different BDI rates according to the estimated price to contract a public work. Those public works were construction of edifices and reforms with until 40% of ampliation, irrigation and channels, basic sanitation, water mains, networks and pumping and treatment stations.

The judgment of the Brazilian Federal Court of Accounts - TCU 2.622/2013 excludes the works of reform and contemplates only BDI for buildings, and other infrastructure projects, and reduced BDI rate for the supply of materials and equipment. Therefore, the criteria established by TCU to the BDI rate are in table 1 and 2:
**Table 1** Judgment 2.369/2011-TCU – BDI for Construction of edifices and Reforms with 40% of Ampliation

<table>
<thead>
<tr>
<th>Description</th>
<th>C. admin</th>
<th>Profit</th>
<th>C. admin</th>
<th>Profit</th>
<th>C. admin</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central administration - profit</td>
<td>up until R$ 150,000.00</td>
<td>5.40%</td>
<td>7.00%</td>
<td>10.00%</td>
<td>9.90%</td>
<td>7.50%</td>
</tr>
<tr>
<td>R$ 150,000.00 until R$ 1,500,000.00</td>
<td>4.90%</td>
<td>6.50%</td>
<td>9.50%</td>
<td>9.40%</td>
<td>7.00%</td>
<td>8.25%</td>
</tr>
<tr>
<td>R$ 1,500,000.00 until R$ 75,000,000.00</td>
<td>4.40%</td>
<td>6.00%</td>
<td>9.00%</td>
<td>8.90%</td>
<td>6.50%</td>
<td>7.75%</td>
</tr>
<tr>
<td>R$ 75,000,000.00 until R$ 150,000,000.00</td>
<td>3.90%</td>
<td>5.50%</td>
<td>8.50%</td>
<td>8.40%</td>
<td>6.00%</td>
<td>7.25%</td>
</tr>
<tr>
<td>Above R$ 150,000,000.00</td>
<td>3.40%</td>
<td>5.00%</td>
<td>8.00%</td>
<td>7.90%</td>
<td>5.50%</td>
<td>6.75%</td>
</tr>
<tr>
<td>Financial Expenses</td>
<td>0.50%</td>
<td>1.50%</td>
<td>1.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance, Risks and Guarantees</td>
<td>0.35%</td>
<td>2.40%</td>
<td>1.32%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>0.00%</td>
<td>0.81%</td>
<td>0.36%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guarantees</td>
<td>0.00%</td>
<td>0.42%</td>
<td>0.21%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple buildings, under favorable conditions and proper implementation schedule</td>
<td>0.35%</td>
<td>0.85%</td>
<td>0.65%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Media complex buildings in areas at / or run under normal running conditions</td>
<td>0.40%</td>
<td>0.98%</td>
<td>0.75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complex works in adverse conditions, rapid pace of execution in restricted areas</td>
<td>0.48%</td>
<td>1.17%</td>
<td>0.90%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>4.85%</td>
<td>6.65%</td>
<td>5.75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISS*</td>
<td>1.20%</td>
<td>Until 3.00%</td>
<td>2.10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIS</td>
<td>0.65%</td>
<td>0.55%</td>
<td>0.66%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COFINS</td>
<td>3.00%</td>
<td>3.00%</td>
<td>3.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BDI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up until R$ 150,000.00</td>
<td>22.40%</td>
<td>31.90%</td>
<td>26.80%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R$ 150,000.00 until R$ 1,500,000.00</td>
<td>21.30%</td>
<td>30.70%</td>
<td>25.70%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R$ 1,500,000.00 until R$ 75,000,000.00</td>
<td>20.10%</td>
<td>29.60%</td>
<td>24.50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R$ 75,000,000.00 until R$ 150,000,000.00</td>
<td>19.00%</td>
<td>28.40%</td>
<td>23.30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above R$ 150,000,000.00</td>
<td>17.90%</td>
<td>27.20%</td>
<td>22.20%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) The percentage of ISS considered 2%, 3.5% e 5% about 50% of the selling price - to observe the law of municipalities.
Table 2 Judgment 2.622/2013-TCU – BDI for Items of materials and Equipment supply only

<table>
<thead>
<tr>
<th>BDI for items of materials and equipment supply</th>
<th>1º Quartil (minimum)</th>
<th>Mean</th>
<th>3º Quartil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11.10%</td>
<td>14.02%</td>
<td>16.80%</td>
</tr>
</tbody>
</table>

In 2011 the federal government in order to encourage the productive sector of the country, established the use of the exemption of the companies payroll, changing the employer contribution of 20% of payroll to social security for tax rates on revenue.

It was created CPRB (social security contribution on gross revenue) and was established the value of 2% for the CPRB in the construction sector and this amount had to be added as an additional item in the “taxes” in the formula of BDI.

With the law 13.161/2015, there was an increase of values for CPRB from 2% to 4.5% for the construction sector. Even after the creation of CPRB there is not a new edition of Judgment that contemplates and revises the boundaries of all the plots and also the final value of the BDI.

During the hiring process work, competitors must each present their BDI values. According to Meneses Filho (2014), some characteristics of the works may affect the company executing the value of your BDI, such as the type of work, the execution time, the value of the work, the geographic location of the same, and the degree of innovation technological. Indirect costs, such as the central administration, are divided among the various works that the company is running simultaneously, then with the amount attributable to each of these works the less the greater the amount of work. Therefore, in principle, a company with great volume of works tends to lower unit costs, then influence the BDI practiced by the company.

But it is important to point out that the BDI rate that should be analyzed by the proposed method differs from BDI practiced by companies because the former is an estimated value for price up to mark the resources needed to employ the work, while the second serves to the evaluation by the bidding committee, responsible for contracting the work, to instruct the future execution of the work contract and its management.

3.6 Other cost basis

According to the legislation, particularly the Federal Decree 7.983/2013, the costs of a reference budget for public works must be based on information SINAPI preferably. However, it is very common in heritage restoration work, the adoption of materials and compositions that are not part of the SINAPI table, simply because these compositions do not represent the services required for this type of work. It is necessary that engineers and architects, in the budget preparation, have to seek other sources of reference from other agencies and other basis, to market price and create their own compositions.

In the latter case, where possible it is recommended using the SINAPI compositions and adapt to the conditions that the project and the work required to better represent the reality of implementation.
Federal Decree 7.983/2013 admits the possibility to meet the peculiarities described above regarding the necessary adjustments to the special character of costs.

The main source of alternative data to SINAPI used in restoration works is the base Sergipe Works cost System - ORSE, developed and maintained by the State Company for Housing and Public Works of Sergipe - CEHOP and the Sanitation Company of Sergipe - DESO.

The ORSE was developed about ten years ago to meet the determination contained in Articles 8 and 9 of State Law 4.189/1999, which created the State System of Registration Prices for Construction and Engineering Services in the State of Sergipe. Currently the ORSE is being adjusted to meet the Federal Decree 7.983/2013, and to adapt to the methodologies and Manual Concepts SINAPI (National System of Costs Survey and Indexes of Construction), and now even incorporate SINAPI of inputs.

There are however some peculiarities and differences between the two systems: some aggregates inputs (e.g., sand and gravel) in SINAPI prices have collected in the field and ORSE have commercial prices for delivery in the city of Aracaju.

Therefore, by adopting ORSE compositions with these SINAPI the inputs, it is necessary to include in an automated way the budgets freight values, and the amount of freight to be adopted will be calculated as the difference between input prices in ORSE (freight) and in SINAPI (without shipping).

As a brief comparison between SINAPI, the reference required by the Federal Decree 7.983 / 2013, and the ORSE base cost, the reference that most closely matches the needs of restoration services, it is not possible to find in SINAPI the service Mortar lime and sand for example, and this service is very common in restoration works.

The ORSE base cost has a number of services related to the most common restorations, whereas the tooling used for certain services are not listed in the supplementary charges, as SINAPI. In the next page there is an example of ORSE composition (Illustration 1).

**Illustration 1** ORSE – Service Composition – 03749/ORSE.

<table>
<thead>
<tr>
<th>03749/ORSE</th>
<th>Mortar lime and sand trace 1: 4 - Mechanical Preparation and transport</th>
<th>m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Composição de preço</td>
<td></td>
</tr>
<tr>
<td>Tipo de item</td>
<td>Code</td>
<td>composition description</td>
</tr>
<tr>
<td>input</td>
<td>00367/SINAPI</td>
<td>Coarse sand - deposit / supplier position (taken in deposit without transport)</td>
</tr>
<tr>
<td>input</td>
<td>01106/SINAPI</td>
<td>Hydrated lime for mortar</td>
</tr>
<tr>
<td>composition</td>
<td>06111/SINAPI</td>
<td>Labour force</td>
</tr>
<tr>
<td>composition</td>
<td>10549/ORSE</td>
<td>Additional charges - labour force</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipments</th>
<th>material</th>
<th>labor</th>
<th>Social charges</th>
<th>others</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
<td>228.63</td>
<td>32.40</td>
<td>36.99</td>
<td>2.87</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>code</th>
<th>Inputs description</th>
<th>unit</th>
<th>amount</th>
<th>Cost unit</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>00158/ORSE</td>
<td>lunch (participation employer)</td>
<td>un</td>
<td>0.8144</td>
<td>4.50</td>
<td>3.66</td>
</tr>
<tr>
<td>00367/SINAPI</td>
<td>coarse sand - deposit / supplier position (taken in deposit without transport)</td>
<td>m3</td>
<td>1.216</td>
<td>73.50</td>
<td>89.38</td>
</tr>
<tr>
<td>12893/SINAPI</td>
<td>safety boots with steel toe and padded collar</td>
<td>par</td>
<td>0.0064</td>
<td>39.60</td>
<td>0.25</td>
</tr>
<tr>
<td>01106/SINAPI</td>
<td>hydrated lime for mortar</td>
<td>kg</td>
<td>182</td>
<td>0.70</td>
<td>127.40</td>
</tr>
<tr>
<td>12894/SINAPI</td>
<td>cover for rain with PVC lining polyester, with hood (yellow or blue)</td>
<td>un</td>
<td>0.0016</td>
<td>10.72</td>
<td>0.02</td>
</tr>
<tr>
<td>12895/SINAPI</td>
<td>front flap safety helmet with polyethylene suspension without jugular (Class B)</td>
<td>un</td>
<td>0.0048</td>
<td>8.25</td>
<td>0.04</td>
</tr>
<tr>
<td>02711/SINAPI</td>
<td>steel barrow capacity 50 to 60 l, tire chamber</td>
<td>un</td>
<td>0.0016</td>
<td>100.00</td>
<td>0.16</td>
</tr>
<tr>
<td>10492/ORSE</td>
<td>Food Basket</td>
<td>un</td>
<td>0.036</td>
<td>100.00</td>
<td>3.60</td>
</tr>
<tr>
<td>10517/ORSE</td>
<td>exams admission / dismissal (checkup)</td>
<td>cj</td>
<td>0.0032</td>
<td>197.00</td>
<td>0.63</td>
</tr>
<tr>
<td>00941/ORSE</td>
<td>uniform</td>
<td>un</td>
<td>0.012</td>
<td>65.00</td>
<td>0.78</td>
</tr>
<tr>
<td>12892/SINAPI</td>
<td>glove leather scrap, short barrel (fst ^ 7 ^ cm)</td>
<td>par</td>
<td>0.0184</td>
<td>7.42</td>
<td>0.14</td>
</tr>
<tr>
<td>04729/ORSE</td>
<td>sledgeshammer 1 kg with cable</td>
<td>un</td>
<td>0.0008</td>
<td>15.80</td>
<td>0.01</td>
</tr>
<tr>
<td>01651/ORSE</td>
<td>white goggles</td>
<td>pr</td>
<td>0.0064</td>
<td>5.36</td>
<td>0.03</td>
</tr>
<tr>
<td>10788/ORSE</td>
<td>square Shovel</td>
<td>un</td>
<td>0.0016</td>
<td>17.29</td>
<td>0.03</td>
</tr>
<tr>
<td>10596/ORSE</td>
<td>Hearing protection</td>
<td>un</td>
<td>0.036</td>
<td>3.20</td>
<td>0.12</td>
</tr>
<tr>
<td>10599/ORSE</td>
<td>sunscreen 30fps</td>
<td>un</td>
<td>0.0144</td>
<td>45.51</td>
<td>0.66</td>
</tr>
<tr>
<td>10761/ORSE</td>
<td>meal - breakfast (coffee with milk and two loaves of bread with butter)</td>
<td>un</td>
<td>0.8144</td>
<td>2.50</td>
<td>2.04</td>
</tr>
<tr>
<td>10362/ORSE</td>
<td>life insurance and accident group</td>
<td>un</td>
<td>0.036</td>
<td>5.65</td>
<td>0.20</td>
</tr>
<tr>
<td>05111/SINAPI</td>
<td>Labour force</td>
<td>h</td>
<td>8</td>
<td>8.67</td>
<td>69.39</td>
</tr>
<tr>
<td>04728/ORSE</td>
<td>lifier flat 10 &quot;</td>
<td>un</td>
<td>0.0024</td>
<td>7.79</td>
<td>0.02</td>
</tr>
<tr>
<td>02378/ORSE</td>
<td>transportation vouchers</td>
<td>un</td>
<td>0.7528</td>
<td>3.10</td>
<td>2.33</td>
</tr>
</tbody>
</table>
We can cite other sources of reference cost data commonly found in budgets of restoration works, such as: SEMINF (Base of City Hall data Manaus-AM), SEINFRA (Secretariat of the Database of Ceará State Infrastructure), SCO (Construction Cost System of the City of Rio de Janeiro), EMOP (Company Database of Public Works of the State of Rio de Janeiro), Setop (State of Minas Gerais Database), information SBC (SBC private company database), TCPO (private company database), market prices, own compositions.

ORSE has several specific services for restoration work, but other cited bases are directed to the works of common construction, and the ORSE, are regional basis, local or methodology and gathering information (prices, etc.) very specific, and mostly without nationwide as SINAPI.

As already mentioned, the Federal Decree 7.983/2013 admits the possibility of using other bases besides SINAPI, but the priority remains the use of SINAPI, the adapted SINAPI (“own composition”) and official data from government agencies bases.

3.7 Methodology

The methodology aims to support the representative of federal funds in their task of analyzing the reference budget before making the transfer, and therefore before bidding to contract the work. Considering then as a starting point the survey of the main requirements of Federal Decree No. 7.983/2013 of Judgments 2.369/2011 and 2.622/2013 of the Brazilian Federal Court of Accounts – TCU, of best practice for analyzing costs and the SINAPI base, It is proposed a methodology that consider the verification of the maximum number of key requirements. First, with respect to the budget, it is necessary to verify the format of the cost table (sequence execution logic, proper organization of items in the code of service in the various bases of reference costs, the quantities and unit costs and subtotal, a clear indication of the base date and the BDI rates applied, the identification of the responsible technician), the existence of calculation memory, the compositions of BDI (for construction work and, reduced rate), the compositions of the laws and social charges applied, and the bases of cost compositions different from SINAPI.

After an initial check of compatibility between designs (architectural, restoration, engineering and complementary - installations and others), technical specifications and related budget, and considering that sufficient compatibility, applies the methodology described below:

- The budget must be in editable electronic means, for example, in the EXCEL spreadsheet software. Divide the cost into two parts: one with items of mobilization, demobilization, construction worksite and local administration, and another with all service items. Although all contribute to the total cost of the work, are the services (second part) that in fact characterize the restoration work or construction work;

- Items of mobilization, demobilization, construction worksite and local administration are then analyzed completely, ie all costs are assessed for the specification, the referenced databases, quantification, unit and total costs and unit compositions. As for the local administration of the work is observed if your quantification is appropriate, if the necessary professionals are related. Mobilization and demobilization must only include the need to cover transportation costs

- Then it is necessary to analyze the service items. Therefore, one should draw the ABC curve of services, ordering in decreasing services for their total costs, and then proceed to the analysis of the
items considered most relevant, i.e. those of the tracks A and B, totaling about 80% of the total cost of the work, and representing at least 10% of the total amount of (Illustration 2).

**Illustration 2 Graphics of ABC Curve.**

These items are then sorted and separated, as the reference source of costs, its representation (in absolute and relative percentage), values (absolute and relative), and generate graphics for better viewing (Illustration 3).

**Illustration 3 Graphics of ABC Curve – Stratification – Cost Basis.**

- The selected items are then subjected to thorough analysis, from the specification, the comparison between the composition of unit cost and the proper execution proposal in the project and other documents, quantification of service, unit cost of composition, value of unit cost, total costs, proper implementation of specific BDI rate for each case (BDI rate of work or BDI reduced rate and differentiated), and inconsistencies are grouped according Illustration 4. The technician responsible for the budget is the one who decides if the compositions of SINAPI meet the design, but in the analysis phase of the reference budget it is checked the choice, before the bidding to contract the work. Once validated the choice, the SINAPI compositions do not require detailed analysis, since it is the official reference base required by the Decree;
• For each service analyzed it is necessary to check the compositions of various reference costs. It is checked if the guidelines of the decree regarding the preference for SINAPI was respected, and if the proper sequence on the choice of other reference bases too;

• In the case of use of market prices to determine the cost of an input (service, equipment or material), it is necessary to adopt the median value of at least three quotations, as understanding of the Brazilian Federal Court of Accounts – TCU.

• It is necessary to check if the quotes have the same scope, if there is a perfect understanding of their information and if there is a way to guarantee the traceability. For items considered special and specific for restoration works, like in restoration of images, furniture and artistic elements, it is necessary to adopt the justifications and specifications certified by the estimator and other experts involved in the project, requesting evidences of responsibility for the information;

• About the compositions of the BDI rates, it is necessary to evaluate their installments according to the judgments of the TCU 2.369/2011 and 2.622/2013. The first BDI to assess the rate for service work and the second to evaluate the differentiated and BDI reduced rate for equipment and materials. It is also necessary to observe that the compositions of the BDI rates contain the portion related to Tax on Gross Revenue - CPRB, as another tax to consider (in compliance with Law 13.161 / 2015 with the inclusion of percentage due to the exoneration payroll). Another portion that requires verification is the one relating to Service Tax - ISS, as this portion should be on average 50% of the municipal law defined tax rate, since this tax is not levied on materials and applied equipment (in accordance Law 116 / 2003.);

• The physical-financial schedule is evaluated for logical sequence and ordering of services and their grouping, and deadlines are checked for sufficient quantification for the development of services. For common services, it is possible to use the best practices for works such as specialized magazines for verification, for example.

• For items considered special and specific restoration, adopt to the justifications and specifications certified by the estimator and other experts involved in the project. With all this information so you
can prepare reports containing the needs adjustments to the assessed cost can be fit and meet the main legal requirements associated with the reference cost for hiring public work of restoration with the use of federal funds.

3.8 Results

For local administration, mobilization, demobilization and construction worksite, the analysis performed on the sample estimates showed the following:

- In the local administration, there are several categories and professional profiles that are not found in SINAPI base. Restorers, craftsmen in general and archaeologists are examples of these categories. For some of these professionals it was used the architect reference costs or engineer (found in SINAPI), by analogy the need for advanced training, such as archaeologists.
- The ORSE base could be the reference to some professionals. Market quotations were necessary to several specific restoration services. For some professionals, like resident engineer, foreman, stockman and watchman SINAPI was enough;
- The mobilization and demobilization in general could be found in SINAPI, or were easily adapted;
- Services related to the construction worksite could also, for the most part, be found in SINAPI. Some characteristics were easily solved with the development of a simple design and their respective composition, as is the case of studio assembly;
- In the case of using market quotations it was observed sometimes the absence of a minimum of three, and even when disposing of three, the mistake of using the average and not the median (value of intermediate position in the grouping of the quotations).
- The absence of three quotations was often because of difficulties in finding the local market suppliers are able to deliver the services, or provide specific inputs related to the restoration. An example of this is the provision of inputs such as gold leaf, Armenian cake, and restoration of masonry services.
- The BDI compositions could be easily framed in TCU Judgements. The BDI rate was framed as reform, by analogy. As for the case of reduced and differentiated BDI for materials and equipment, was adopted as base the Judgment 2.622/2013.
- The disbursement schedule (physical-financial schedule) for the most part were considered adequate, the sequencing and grouping of services. In some cases it was verified the need of adjustments on the local administration of the residence time for example.
- As for the services of the ranges A and B of the ABC curve, the analysis performed on the sample estimates showed the following:
  - Various services presented in SINAPI, developed for construction, might have been used, with or without adaptations in their unit cost compositions.
  - Other reference databases of works costs were used or adapted to the needs and particularities of the projects. In many cases it was necessary to use market prices for both budgeting services as inputs;
Various types of restoration services were found in the various types of buildings evaluated and also get close relatively quite to contemporary services performed in public works.

Unit costs compositions have been developed with the establishment of the relationship of inputs (labor, materials and equipment);

In the sample of analyzed budgets, it was possible to find the frequency of each cost base: SINAPI (92% of sample estimates), ORSE (46%), Setop (23%), CEHOP (7%), SEINFRA (in 15%) SCO (7%), SBC (31%), market quotations (54%) and suitable compositions (92%);

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All the frequency of costs basis are in table 3.

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<tr>
<th>Tipo</th>
<th>% Sinapi</th>
<th>% Quotation</th>
<th>% Own Comp</th>
<th>% ORSE</th>
<th>% Setop</th>
<th>% Cehop</th>
<th>% Seinfra</th>
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C: Civil Architecture
O: Oficial Architecture
R: Religious Architecture

In none of the cases analyzed all the cost items was only the SINAPI. This reference system had its highest percentage of use in an example of religious architecture, reaching 71% of its cost (items the tracks A and B);

It was also a church that the use of own compositions reached its highest percentage, reaching 64% of the budget items (items of tracks A and B);

The highest percentage of use achieved market prices was 46% (items of tracks A and B) in a case of civil architecture (market);

The ORSE system reached its highest percentage of use, 67% of the items of the tracks A and B of the...
cost of a church;
- The Setop reference reached the percentage of 58% in the case of fortification;
- The SBC system reached 16% of the items of the tracks A and B in a case of church;
- In the three churches that have integrated goods (60% of the analyzed churches), one of them was used ORSE system to restore services of these elements in other two were his own compositions. Still, in these cases the reference SINAPI was used for the remaining services in each of the estimates;
- The most references present in church restoration budgets were SINAPI (present in all the budgets of the churches), own compositions (in 80% of them), ORSE (60% of them), Setop and SEIMFRA (20% each);
- For copies of the official architecture, SINAPI was present in 67% of their budgets, prices by 67%, own compositions at 100%, 67% and Setop ORSE 33%;
- For costs to official architecture, SINAPI was present in 100% of costs, as well as their own compositions and quotations. The ORSE was 40%, and CEHOP SEIMFRA 20% each;
- The own compositions were prepared both by adapting SINAPI compositions and other bases, such as those created without references, with inputs and consumption rates of those created specifically for that work, so very special for each project and construction;

4 CONCLUSIONS

The Federal Decree 7.983/2013, the judgments of the Federal Court of Accounts - TCU - and the official basis of construction costs, such as SINAPI, represent an important instrument to guide the costs analyzes of public restoration works. The SINAPI system was not enough to supply a large part of important services required for the type of restoration works. There are many similarities and differences between restoration works and civil construction works, and it is timely to develop a cost reference to restoration public works in Brazil.

On the one hand they count on the need to establish references for the craftsmen, it is coming up on the fact that the costs of these professionals (considering the artisanal aspect of its services, the degree of difficulty of the service, the materials involved, etc. ..) can vary widely. For these, the most appropriate would even work with market quotations for their proper lifting costs for the work. This is also a result of low organization of these professionals in representative bodies that could at least establish minimum fees.

Demand for archaeologists in environmental licensing and monitoring of the works is new reality in Brazil. There has been a great demand for these professionals, but still not able to determine precisely the adequate remuneration, and therefore their costs for the works.

The parameters set by the TCU were apparently adequate and sufficient for the BDI of restoration. Perhaps the lack of subsidies and studies to establish different criteria TCU, detailing specific characteristics related to the indirect costs of restoration companies, the fact is that it has not found any composition or argument to defer the court’s standards. It should explore this issue in future studies to actually verify
the adequacy of the BDI values established by TCU to works of common construction, the restoration works. It is important to develop other studies about the BDI rate for companies of restoration works, and verify if the reality of the market for those companies is the same or similar to the civil construction.

Faced with SINAPI gaps for restoration work and the possibility of developing compositions for various specific services, it is concluded on the feasibility of developing a proper baseline costs for restoration services, primarily when dealing with public works. Just as when using SINAPI compositions analyses are simplified and restricted quantities and unit costs, the use of a base for restoration services, duly developed and approved by most of the Heritage agency in Brazil, Iphan, and submitted to the Ministry of Planning, as recommended by the Federal Decree 7983/2013, organize the market, desing companies, construction companies, and facilitate the development and analysis of costs, in addition to the audits carried out by various bodies and society. To develop this cost base it is important to consider the most common cost basis and its frequency in the study.

The proposed methodology proved very efficient in checking compliance with the requirements of the Federal Decree 7.983/2013, with the requirements of the Brazilian Federal Court of Accounts – TCU and other legal requirements. It is an important tool in budget analysis, as required by Federal Decree, and also showed the possibilities and opportunities to develop a specific cost base for restoration.

5 REFERENCES


A case study of Innovation and Strategic Governance – School refurbishment program in Portugal

ABSTRACT

Purpose of this paper

From 2005 until nowadays, interesting steps have been taken towards the integration of innovative solutions and global construction process improvement in Portugal. A milestone on this process was the publication in 2008 of the Public Procurement Code, a legal framework that set new provisions, as well as requirements and targets/achievements. Parque Escolar, EPE, a public entity with the responsibility of managing the school refurbishment program, had to test new methodologies due to the ambitious construction/refurbishment plan that was in progress (modernization of 300 schools). The present work describes the main actions taken and the achieved results.

Design/methodology/approach

One of the initiatives that had more impact was the adoption of ProNIC - Construction Information Standardization Protocol. Given the number of construction works/contracts, nearly 100 schools, the implementation was very demanding in terms of training, stakeholders follow up and support infrastructure. The description of ProNIC essential elements and the key factors for the achievements are explored. The implementation process was soften during 2010 due to the investment reduction on public works.

Findings and value

Notwithstanding, ProNIC is nowadays managing more than 80 projects, representing a direct investment of more than 1.1 billion euros. One of the most interesting output is that, through the use of standardized bill of quantities it is possible to know for each work, the number of times that was used, the amounts of work set/built, as well as budget estimates/winning bids cost comparison.

Originality/value of paper

This endeavour introduced many innovations, and it is possible to state that it is still absolutely pioneer on the Portuguese construction due to its dimension, complexity and outputs.

Many of the benefits have direct application on the construction process and therefore they can be easily identifiable. Other benefits are still being studied has their quantification is more difficult. Among them we can find savings in terms of time and money on the entire process management.

Keyword: standardization, control, management, efficiency, integration
1 INTRODUCTION

The excessive fragmentation of the construction industry and the losses in terms of effort and information, among other problems, led this industry to very low productivity levels. Yet, the sector is responsible for a huge amount of employments and an important percentage of countries GDP, Mêda P., 2014. Many authors state that construction lost its position on industrial leadership. Given its relevance it is urgent to reinvent the activity and at the same time produce more environment friendly constructions.

Words such and efficiency, sustainability, competitiveness are placed on every construction strategies across the world, European Commission, 2012. Public investment is a strong way to foster the industry to be committed with these targets. Yet, and in order to do it, the Public Owners need to work as innovation enablers, raising the bar in terms of requirements and also in terms of solutions/tools to support the achievement of the targets. Knowledge, confidence and strategy are therefore necessary across all stakeholders.

These ingredients were gathered on the initiative that this paper presents. It is found to be a successfully case study that can provide good inputs for other similar initiatives and to foster others not only in Portugal but also in other realities.

2 CONSTRUCTION INNOVATION IN PORTUGAL – LEGAL FRAMEWORK AND SUPPORT TOOLS

2.1 Overview

From the mid 90’s until present time, the construction industry in Portugal experienced strong changes at distinct levels. In terms of economic relevance, construction and namely Public Works, represented a significant part of the country GDP until the moment of the crisis, by the end of 00’s, Figure 1, INE, 2015. During this period, most of the large projects were developed with European Funds, where growing requirements were set.
New legal frameworks and the application of European standards raised the construction requirements. In terms of construction process, there were many changes regarding the design activity, namely new regulations, more design disciplines and increasing requirements. From construction point of view growing requirements were set in terms of health, safety and security on the yard, as well as environmental behaviour. The construction companies improved their quality procedures. From the information technologies point of view, growing number of software was adopted to develop specific tasks, from structures and systems dimensioning, to construction planning, budgeting, drawings development, among others. Recently a work developed by the Information Systems Group from the Portuguese Construction Technology Platform (PTPC GT-SIC) identified the most used software across the process as well as the type of tasks, GT-SIC, 2015. These tools introduced large benefits for the productive chain. Yet, the development of common rules and standards for the process development and outputs was lacking. During the 00’s, projects at different levels started to work this situation. From the regulation (legal diplomas) point of view to guiding solutions, large work was developed setting requirements and providing solutions to the different stakeholders on the different stages of the construction process, structured from a life cycle vision, Figure 2, Mêda, P., 2015.

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**Fig.1** – Construction Industry relevance compared with the Portuguese Gross Domestic Product (GDP).

**Fig.2** – Construction process life-cycle, RIBA Plan of Work and Portuguese Framework.
The following points explore the steps taken regarding legal frameworks and supporting tools for construction process development, namely on Public Works.

2.2 New legal framework

The Public Procurement Code (CCP), Decreto-Lei n.º 18/2008, set new requirements for the construction process as well as a new vision in terms of project delivery, namely during procurement procedure. This document resulted from the update of the previous national Public Works framework, the Decreto-Lei n.º 59/1999 and the transposition of the EU Directive (2004/18/CE) on Public Contracts. The mandatory adoption of eProcurement can be identified as one of the major innovations, as it introduced completely new procedures and high requirements in terms of technology. Public entities, design and supervision companies and contractors started to deal with this new reality on a daily basis. Additionally, the new framework made possible the clarification of many aspects related with the construction process management. The publication of this diploma matched in time with the delivery of the ProNIC project, that it will be further explored.

From the global changes there are some that given its importance worth to be highlighted. Portaria n.º 701-H/2008 is one of the most important diplomas that complements the CCP. On its provisions sets the rules for the design stage in terms of deliverables, design organization (in disciplines) and global requirements for final design delivery. It also sets the moments in which the design stage can be divided.

The use of electronic procurement for all tender actions under CCP framework was, as stated, the most innovative aspect of the document, in what relates to information technologies and procedures, Sousa, H. 2008. With the new CCP it was created an instrument geared for the monitoring of the construction activity, the Observatório das Obras Públicas (Public Works Observatory). This instrument collects and delivers data from all the public works, namely during the contract signature. It is meant to be extended to other information, namely deviation in terms of total cost and schedule.

2.3 ProNIC – Construction Information Standardization Protocol

ProNIC development started in 2006. It was a Government promoted initiative, through three public entities/public work owners, with the scope of filling missing links in terms of information standardization, mainly in what was related with construction work descriptions and technical specifications. The goal was to produce structured information that could allow guidance and standardization principles for the bill of quantities production (essential element to be produced and delivered at the end of the design stage) as well as technical specifications for the construction works and construction products. All the information should follow the most recent legal documents and standards. Given the broad scope of the construction in terms of complexes and construction types, the first development focused on information for building construction and refurbishment, namely residential and road construction, that were the core activities of the above mentioned entities, Sousa, H.2008.

On the basis of this standardization protocol is the philosophy of the Construction Information Classification Systems, or CICS. These tools have been developed since the 40’s and given their importance and evolution worth to be worked by the International Standardization Organization (ISO) that developed...

ProNIC’s development followed the example of some of the more relevant international initiatives, such as the British Uniclass, the Masterformat from USA or the Spanish Base de datos de construcción. These provided useful knowledge in order to develop a wider and more integrated information architecture. National guidelines and documents were used and their information updated. Most of the collected information was paper based and structured to be operated manually. One of the main objectives was to set an information framework within a tool that could be used as an interface for the design documents production. Therefore the technical information database was equipped with a functional interface for the users. Figure 3 provides a brief resume on the information elements and main outputs.

Fig.3 – Information elements and main outputs.

The information element that links all the others is the Work Breakdown Structure – CW. According with ISO 12006-2 standard on its 2015 version, this table is one of the most used within the Construction Information Classification Systems, Owen, R., 2013. It plays an essential role on the organization of the bill of quantities.

In ProNIC, the development of this table was set to a singular level of detail. Most common systems, such as the mentioned, are composed of a hierarchic structure where the most detailed level defines a construction element and its location/composition. ProNIC goes further by setting standardized work descriptions with the intention of writing the bill of quantities. This description can be parameterized and it is followed by the need of setting a measurement criteria. This effort constituted an evolution and it set the base for developments on other commercial tools. Given the scope of the project and the
different owners initially the tool was set with two information databases, one for building and other for roads. Yet, the trends were pointing to other direction. During the following development phases, the two databases were gathered. Nowadays there is a single one that can give answer to buildings and roads. A new project is undergoing and it will lead to an expansion in order to meet the needs of other construction types, such as railways, piping systems, among others.

The tool was designed to work on a standalone base or in a collaborative workspace. The first option was never tested as it was found more useful the use of a collaborative environment for the design development and coordination. The project was delivered in 2008.

2.4 Combination of requirements and tools

The publication of the new framework and ProNIC delivery occurred with few months of difference, ProNIC was delivered first. With the new legal framework some non-specified situations related with design organization and other requirements were clarified. In this respect, the Portaria 701-H/2008 played an essential role on these definitions.

In order to provide a technological solution to the new requirements and clarifications, adjustments and new functionalities were introduced in ProNIC in order to set a more complete and collaborative environment for the design stage and for the design delivery, Mêda, P., 2014. At this moment, the main focus was geared for the design stage. Notwithstanding, the processes and possible integrations/information exchanges and new functionalities on the following procedures and stages start to be studied. Among these was the communication of ProNIC with the electronic procurement platforms and specific functionalities and information exchange flows during the construction stage.

3 PARQUE ESCOLAR SCHOOL REFURBISHMENT PROGRAM

3.1 School Buildings network

In Portugal, the secondary school network is composed by 477 complexes that were built in different periods. From the general overview of the different types of construction resulted three groups of buildings. The ones built until 1935, the group from 1936 to 1968 and the group of schools built from 1968 until 2000. In terms of number, nearly 23% are framed on the first two groups and the rest on the 3rd group. On this last, 46% of the complexes were built during the 80’s, Parque Escolar, 2011. Therefore, and in what regards to this specific network, the effort of the past three decades was mainly geared for the expansion, using for that purpose standard technical solutions and standard construction series. Thus, the effort not allowed to develop in parallel a constant and consistent practice, both in terms of conservation and maintenance of existing buildings and in terms of its functional adjustment to reflect modifications that have taken place in terms of curricula, educational and training practices. Non-integrated measures have been taken to cope the deterioration caused by the use and construction problems that buildings are subject during their lifetime (despite their high physical strength demonstrated). In addition, the extension of mandatory education until the 12th grade, the requirements and identified needs in terms of comfort, environment, infrastructure (namely communications and specific equipment’s) and even furniture were increasing, demanding a structured approach for these interventions.
3.2 Refurbishment plan

During the 00's, the Portuguese Government drawn an ambitious plan for schools refurbishment with the scope of raising the average school conditions in the country. This program would benefit from the use of Communitarian Funds geared for education conditions. It was grounded in three fundamental objectives:

- Restoration and modernization of the school facilities to foster a culture of learning, knowledge dissemination and skills acquisition;
- Open the school to the community, namely through the use of the facilities on activities outside the class schedules;
- Creation of an efficient and effective system for buildings management.

It set the modernization of 332 complexes until the end of 2015. These works were framed in phases that would allow the validation of processes, technical construction solutions, support models, management of the construction process and the management throughout the in use stage. The first phase, named “0” was composed by 4 complexes. The chosen buildings constituted situations where the intervention was more urgent as well as others where the complexity was higher. This phase was launched in 2007. The “phase 1” involved 26 complexes and the “phase 2” 75. These were all launched until 2009, Parque Escolar, 2015. The experience from the first projects led to the identification of several situations where an improved information organization during design and construction would provide benefits for the management of the entire project and use stage. In addition, the mentioned new legal framework was introduced where many related requirements would become in short time mandatory.

4 PRONIC IMPLEMENTATION AT PARQUE ESCOLAR

4.1 Scope/objectives

During 2009, Parque Escolar, EPE that is the Portuguese Government entity (Ministry of Education) responsible for planning, managing and developing the secondary schools refurbishment program, decided to set the mandatory use of ProNIC on the “phase 3” of its program. This phase comprehended one hundred school complexes and an estimated total investment of approximately 2000 million euros.

A school is a complex building type due to its dimension and requirements in terms of spaces, systems and equipment's. Following the legal framework each process involved nearly twenty five design disciplines. In order to validate the structure to be adopted, identify the major needs in terms of construction works to be included on the WBS and to obtain an improved knowledge about the complexity of this type of facilities a test was developed with two case studies from the previous phase of the program. Following this, adaptations were made in order to:

- set an improved project conceptual structure that could support the definition of construction units (Figure 4);
- support construction works that were not foreseen for residential buildings, namely HVAC equip-
• standardize the information framework and the processes of the different agents involved in the different works, namely during the design stage;
• acquire an improved capacity for monitoring and compare different procedures through the use of standard references;
• improve the technical quality of the interventions in terms of construction technologies and support information (technical specifications);
• global improvement of construction costs monitoring capability;
• improve the overall program management through the systematization of information for the use stage;
• reduce the loss of information, reworks and non-productive through the creation of a common framework;
• streamline procedures through systematization and standardization;

Achieve on the 3rd phase of its investment program a level of systematization and innovation in the construction process without parallel on the Portuguese reality, leading to an improved compliance of the legal requirements and producing several savings, namely in terms of resources.
4.2 Design stage

The initial step was the implementation of ProNIC on the design stage. The goal was to deliver the consolidated and standardized bill of quantities. This document should reflect the works to be developed in each Construction Unit and identify the design discipline that defined each work.

For each process it was set a project in ProNIC with the school designation. The permissions were set for each member of the design team that had a specific access and role. For each project the Construction Units were defined on a meeting involving the design team and the owner. A group of pre-established works was placed on the project. These were mainly related with yard, preliminary works and furniture. They were set without quantities and unitary prices. This definition was part of the work to develop during the design stage.

Each design discipline had do produce from the beginning their bill of quantities. The way to set construction works was through the WBS-CW following the divisions until the specific work, as previously mentioned. Each work has requirements/parameters that need to be fulfilled by the designers. These reflect characteristics that must be placed on the CE mark and on the Declaration of Performance, as well as technical characteristics, dimensions among others. Figure 5 identifies the information groups within each work description.
Following the description, it becomes necessary to set rules of measurement or criteria. Quantities and unitary prices can be introduced on each work specific fields or can be imported to the application through an .xls template that can be worked outside ProNIC. The possibility of developing work outside the application through the use of information templates on more common tools, such as spreadsheets, was found essential in order to establish a link between the new technology and common practices. It is found that this situation constituted a fundamental aspect for the adoption and success of the implementation.

It is reasonable to state that the level of innovation introduced was quite high. In addition, the time to develop the design stage was tight facing the new requirements (here it worth’s to highlight just the changes introduced by the new legal framework). The two situations combined constitute an adverse scenario for the type of process that was undergoing. The key aspect for the success was the introduction of innovation without disruption with the common practices. That is, the need for cultural change was underlined and the agents develop different feelings about it. Notwithstanding, if there are still traditional processes or tools that are well known and continue to be part of the process, the reaction is less adverse as there is confidence regarding these processes. One key aspect on working with these tools is that the template must be organized and with rules, in order to be accepted by the systems and to provide a more effective output, Sousa, H., 2012. The awareness for this situation on the training actions was one of the keys to motivate the agents. Through the repetition of the previously mentioned process of introducing the construction works on the project, the bill of quantities was set for each discipline. It is important to highlight that this work can be reused on other projects through an import functionality. This was very useful for many design disciplines, namely those that already used the same construction technologies and construction materials on different projects. By setting the bill of quantities, the general technical specifications were automatically developed. In terms of written parts, particular technical specifications and brief description could be developed outside ProNIC and imported to the project.
folders. The same situation should occur with the drawings and other required documents. After the design coordinator analysis and revisions, a global validation of the design is performed and the design is ready for delivery. This delivery is structured in three steps. The first is to close the different design disciplines. Each designer places a digital signature on its documents. With all the disciplines closed, the design coordinator closed the design and it becomes ready to be delivered. The final step is to deliver the design to the owner. From this point the owner has access to the process and can send it back for revisions or accept it for the preparation of the tender action.

4.3 Tendering action

As previously mentioned, one of the major innovations introduced by the 2008 Public Procurement Code was the adoption of e-procurement. Initially, it was introduced for acquisitions of products and services. In 2009 it became mandatory for public works with temporary exceptions for some owners. All the projects within “phase 3” would need to be launched via e-procurement.

From the lessons learned from other owners, there were difficulties on performing the process due to the size of the documents and the complexity of the folder system that constituted the global specifications, design and administrative provisions. The upload of the process was quite slow and the agents were struggling with lack of speed of the internet connections. Some improvements and solutions were implemented in order to solve the situation, but it was still a very time consuming effort, Mèda, P., 2012. To anticipate these problems, ProNIC team developed in the system functionalities to streamline the exchange process. As mentioned above, from the end of the design stage it resulted the complete design structured within the ProNIC, validated by the design team and accepted by the owner. This was an information package that was organized and ready to be sent to other stakeholder. Therefore a tender screen was developed in order to assemble the bidding process according with the CCP provisions. Specific permissions were structured for this process, from the owner perspective and an exchange protocol was settled with the e-procurement platform used by this public owner. The tender screen allows the definition of the tender notice information as well as the upload of the required documents such as administrative provisions. Completing this process and through the activation of the “send” button, all the process is automatically placed on the e-procurement platform; Figure 6.

The legal framework sets a negotiation part before selecting the contractor. During this period there are two processes that involve information exchange between the bidding agents (contractors) and the owner. From these processes result changes on the design documents, namely an update of the bill of quantities. Functionalities were developed in order to support these requirements. The need for validation is similar to the one previously mentioned for the end of the design stage. Figure 6 represents a resume of the information exchanges during procurement.

4.4 Construction stage

Following the procurement procedure, there is the selection of the winning bid. New functionalities in order to introduce this document were developed along with all the required information regarding the winner (contractor designation, contract description, among others). The unitary prices from the budget estimate are replaced with the ones from the winning bid. During the construction stage the CCP sets
the production of monthly measurement reports for the effective control of the works performed and to support the payments to the contractor. This process is carried out by the contractor with the participation of the supervision team. This document is sent to the owner that must accept it in order to authorize the emission of the invoice.

One other document that needs to be produced is the “balance account”. It is a resumed checking between the works performed and those missing. It is also monthly based. To streamline this process, that is usually made using spreadsheets, the information is produced on a template with the referred format and with specific rules for its fulfilment. The supervision team downloads the template and gives it to the contractor that fulfils it with the executed work quantities. Then, both verify the document and in case of agreement they perform the upload to ProNIC and continue the process by placing the required digital signatures. Then, the owner can accept or send the document back for revision. If it is accepted the process is concluded and it becomes possible to produce the following template that will incorporate all the previous uploaded information. This process continues until the end of the work and it is followed by the production of the “balance account” document.

![Diagram](image)

**Fig.6 – Information exchange during procurement stage between users and applications, Méda, P., 2014.**

CCP sets the possibility of contract changes, due to claims or additional works. In resume, these can lead to the suppression of works, to new works (not foreseen) or to errors on the measurement that need to be corrected (more or less work quantities). In these situations additional contracts need to be performed. A step further on ProNIC functionalities was the development of mechanisms to accommodate these processes. The additional contracts are developed in parallel and articulated when necessary with the original contract. Global bill of quantities can be produced at each moment. CCP also sets limits, in terms of amounts, for these changes. The contract needs to be maintained within those limits. ProNIC
developed a report that validates the possibility of performing the changes observing the limits. Figure 7 resumes these actions.

In what regards the monthly measurement reports and the contract changes, it is in conclusion the process of establishing communication between ProNIC and the ERP software for the financial control of the works. ProNIC sends the technical information that supports the invoices and payments performed on the ERP, Mêda, P., 2012.

### Construction phase management

<table>
<thead>
<tr>
<th>Construction works – Initial Contract</th>
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<th>Other related processes</th>
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<tr>
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<td>Values for future investments analysis</td>
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**Fig. 7** – Example of information gathered for a work and initial statistical treatment, Mêda, P., 2014

### 4.5 Examples of achieved information

During the different stages previously mentioned and at the end of the construction, the work owner has the possibility of exploring large amounts of information. This information is standardized in content and format. Cost indicators are the most explored.

Given the use of standard work descriptions it becomes possible the direct comparison of the same work across several construction works. It is also possible to explore the information on higher levels such as the construction unit level, design disciplines, WBS-CW chapters or groups of works. These can be crossed with the project metadata (global cost, square meters, students, chairs, computers, etc.) in order to give the most useful information.

These indicators fulfil also the requirements foreseen for the previously mentioned Observatório das Obras Públicas.
The following parts present examples of the potential exploration of this information.

4.5.1 Work level

As mentioned, it is possible to obtain the unitary prices practiced for the same work on different projects. Each project has specific characteristics as location and the works have also singularities that have direct influence over the cost. The amount of work is one relevant aspect.

The example presented on Figure 8 addresses to the results of the work of placing electrical conductors made of plastic on the interior of masonry walls. The measurement criteria is meter. The work was used in 69 different projects. The global quantity placed was 160137,50 meters. The highest price practiced was 4,71 €/m. The lowest was 1,17 €/m. The mean value achieved, and that can be faced as reference on budget estimates is 2,02 €/m.

Fig.8 – Unitary prices used for the same construction work on different projects

One other example of information that can be explored at the work level is the difference between the values of the budget estimate and the unitary prices practiced by the winning contractors. There is also the possibility of setting the comparison with all the contractors involved on the tender action. The following example addresses to the first situation. Without cost references, the budget estimate can be unreliable. It is understandable the difficulty of setting a unitary price based on the information provided by manufacturers or catalogues. Many times the price set does not represents the real value of the work. The same situation occurs with the contractors where the risks taken are higher and therefore the prices may reflect different assumptions, knowledge, behaviour on the industry, among others.

The example presented on Figure 9 was selected as it gathers all the characteristics and reflects all the previous mentioned aspects used by the different agents. A hand dryer is an equipment that can present different characteristics in terms of aspect and performance. Therefore the prices practiced in each project reflect those differences. The interesting point to explore with this example, as stated, is in each
project the difference between the budget estimate and the winning bid. The construction work was used in 20 different projects and it would be expectable that the values from the budget estimate would be higher than the ones from the winning bids. In fact, this situation and with reasonable differences occurs only in 7 situations. It worth's to highlight 8 situations where the differences between the values are very expressive and even unreasonable. Situations as the number one and eleven represent high risk taken by the contractor.

![Fig.9](image) – Differences on the unitary prices set on the final budget estimate and on the winning bids for the same construction work on different projects

### 4.5.2 Global investment level

The high level indicators address to the global investment by project. This information can be crossed with metadata providing different types of cost analysis. The following examples address to the cost by square meter and by student for a group of nearly 150 different projects. As mentioned, these are from school refurbishment processes and therefore some variations occur depending on the type and condition of the pre-existence.

The cost by square meter indicator presented in Figure 10 evidences that there are big similarities among the projects. Similar situation occurs when the project investment is crossed with the number of students, Figure 11. A linear trend can be drawn in order to get a preliminary budget depending on the number of students and compare the achieved value with the area of intervention multiplied by € 400,00.
The mentioned indicators can provide the main guidelines for a preliminary budget definition. Further interactions can be made using other indicators such as the relevance of different design disciplines on the project as well as the generic investment values by discipline and square meter.

5 RESULTS AND FUTURE STEPS

Presently, ProNIC is used on all the Parque Escolar, EPE construction works, from the design stage until the end of construction. More than 1100 million euros are being managed and it is possible to state that
the implementation process was a success. Notwithstanding, it necessary the awareness that once in operation the maintenance and improvement of the workability demands a continued effort in order to support and help the different agents involved on the process. From the lessons learned it is found essential the existence of preliminary training actions geared for specific agents, such as designers. Their objective should be to provide initial training for the professionals on the most important concepts and functionalities. These should be structured by agent role.

Then, in a second moment, the actions should be undertaken by design discipline, in order to explore real work situations, compare the different design traditions, explore specific chapters of the WBS and clarify the best options to develop the work. Continuous helpdesk and specific/periodic training actions should also be settled to clarify advanced users, to listen their options and to evaluate their work options.

On the other hand, a continuous close contact with the users allows improvements on the system workability, as shortcuts, streamlined work methodologies and complete use of the functionalities can be explored.

From the owner point of view and taking in consideration the initial objectives, it is possible to state that the level of control and information awareness/usability is not comparable with the situation before ProNIC. The extension of the functionalities and the integration with other tools allows a complete use and control of the information. These two dimensions can be translated in examples such as:

- the construction works report that gives automatically, for each work of the database, the amount of work developed on each project (and its divisions), the price set by the design team, the price of the different proposals and the one from the winning bid;
- the “As built” bill of quantities, that results from the winning bid and changes occurred during the project, from the tender process to the end of construction. It reflects the changes occurred in terms of works, quantities and prices (when applicable);
- the interaction with other tools for the production of documents such as invoices, as well as the definition of an coherent information background where there is a definition of a single place for different types of information.

It worth's to point that during the development of “phase 3” the country entered on a severe economic crisis, Mêda, P et al., 2014. Many processes were stopped and many contractors were replaced. The volume of loss information was significant lower due to the use of ProNIC.

It is possible to state that the implementation level is in different steps in what relates to the construction process stages. This is directly related with the moment of the implementation and the routines developed. Most of the agents work without difficulties on the design and procurement stage, but there is still a long way on other processes, namely on the construction stage and on the use of the information or indictors.

In what regards the design teams, there was very positive feedback from the beginning and some less positive situations. Many of these were changed at the end of the construction due to the perception of
the reached benefits. This results on a positive overall balance. Two main reasons are identified as key factors for the results. There was always an information referential, that was the information within the application and there were less problems in what relates to claims during procurement and construction.

The global quantification of the improvements is rather difficult if we try to set a comparison with the amount of investment. This would just reflect the overall process improvement, that is considerably high, due to the situations mentioned, but it can reflect more effort from some agents on the initial phases. In order to better understand and quantify these results, a detailed study is being developed.

6 CONCLUSIONS

The construction process productive chain is complex and uses huge amounts of information, Mêda, P., 2014. The introduction of innovation on construction must be straightforward and supported by national level strategies. Innovation and competitiveness should leverage the industry on the following years. Yet, these actions must be undertaken avoiding practical and cultural disruptions. Resistance to change constitutes the most relevant difficulty on all sectors and construction is by far no exception. This industry is composed by very different persons and the success of implementations such as the one presented lye on the ability to introduce innovation without disruption. The maturity levels of UK BIM strategy reflect this concern, HM Government, 2013.

The development of software and systems that can work together across the construction process and with its boundaries must be fostered. Interoperability and integration assume here a major role.

ProNIC was classified initially as a construction information classification system. In essence, part of its information is a CICS and it is found to be the main driver of the rest of the database and functionalities. Notwithstanding, the global application itself can be classified as an Integrated Design and Project Delivery tool, Mêda, P., 2014. Grounded on the technical information that supports the construction process it crosses the different stages setting standard processes, requirements in terms of information and documents, information exchange protocols, interactions between agents and different tools, Mêda, P et al., 2014.

In what regards the specific situation described on this paper, it worth's to highlight that:

◊ the described implementation experience was quite demanding due to the amount of works and investment, number of involved agents, complexity and time to produce results;
◊ the lessons learned evidence that the options taken were correct and should be replicated on future situations (other public owners);
◊ similar effort in terms of training should be placed if the type of construction is a building (residential or services). Particular effort should be made with owners in order to identify blanks on specific works;
◊ future situations on owners more geared for other types of works, such as infrastructures, it is advisable to develop an initial test phase in order to understand the requirements in terms of WBS-CW and specification developments. The use of large case studies helps on this identification;
the level of integration between stages, agents and software is not comparable with other initiative on the industry. The amount of information and the ability to manage it, constitutes a singular example;

the Portuguese account court of auditors identified ProNIC as a tool to improve the control cost on the construction industry, as it also supports the development of auditing processes.

Continuous effort is being made towards the update and extension of the use and functionalities of ProNIC. Presently, the legal framework is being revised and new requirements related with life cycle cost analysis are being foreseen. The information provided by ProNIC can be very useful. A new project is being prepared in order to adapt the tool to the new requirements, extend the contents and functionalities, as well as develop integration protocols with other software.

7 REFERENCES


Success Driven Project Management: Planning and Controlling cost, time, scope & risks with the calculation of success probability trends

Liberzon, Vladimir; Mello, Peter; Guimarães, Jefferson Fern; Edward J.

ABSTRACT

For larger projects, there are lots of things that can change while the work of the project is being performed. The supply of money may grow or shrink. The demands of potential customers for, or users of, the product of the project may change. Advances in available technology may modify the requirements, making them more difficult or easier to accomplish. Talented human resources may depart from, or sign on to the project. Physical resources may become scarcer or more plentiful. Tools may become more powerful. These changes can occur at any moment, dictating variations to our plan for completing the project. If to continue to pursue the original plan, one will deliver either something less than we might have or nothing at all. This harsh reality, in turn, dictates that one must have a clear idea of where one is when these changes occur, what progress has been made and what, given the new reality, remains to be done. In other words, measuring progress against the original plan simply is not enough.

Success Driven Project Management (SDPM) is the Russian Project Management Methodology that integrates risk, cost, time and scope management. Project teams plan, execute and control analysing the trends of the probability of successfully meeting project targets. These targets may be set for scope, cost, time basing on project uncertainty and risk simulation. The use of systematic detailed planning and control improves the reliability of cost and time estimates.

The management by trends and money/time buffers built from the risk scenarios offers an integrated perspective of risk, time, scope and costs not available in other project management methodologies.

Purpose of this paper (mandatory)

The purpose of this paper is to demonstrate that the development of probabilistic scheduling with detailed cost estimates is an effective mechanism for integrating scope, cost, time and risks. Our choice aims at a method that offers effective mechanisms to deal with planning and controlling projects assisted by trend analysis and buffer calculations, increasing the team’s ability to set achievable project targets and to anticipate changes to the original plan necessary for sustaining the original targets within
an agreed budget and use of resources.

**Design/methodology/approach (mandatory)**

The concepts presented in the Russian Project Management Methodology called **SDPM – Success Driven Project Management** are applied in the development of a project schedule for data evaluation of expected results.

The authors’ conclusions are based in the analysis of data and information obtained by the application of the SDPM, as it has been amply demonstrated in different papers which were presented in several PMI and IPMA events, and as we now intend to demonstrate in detail in the present paper.

**Findings and value (mandatory)**

SDPM offers mechanisms to complement project planning and controls based on the analysis of future project activities and it can be applied with the use of Monte Carlo Simulation as well. It offers senior management a clear mechanism for trend analysis of scope, time, and cost, supporting timely management decisions for improving or recuperating project performance.

**Originality/value of paper (mandatory)**

Success Driven Project Management has been used in countries from the former Soviet Union, but it has not yet received adequate attention to its application in the Western World. This paper promotes its use in Brazil and its neighbours, supporting a practical application to projects and portfolios that must deal with cost/resource constraints as a replacement for the use of Critical Path Method. One of the mandatory steps to the use of SDPM is the application of the Resource Critical Path, which is described in ISO 21.500:2012 - Guidance on project management (3.11). This paper offers practical examples about the importance of the use of resource constraints in scheduling, including costs, people, machinery and materials.

**Conclusions**

Success Driven Project Management is an effective management methodology that will guide project decisions based in the success probability calculation of achieving goals aligned with the customer or the team. The method will depend of the construction of three-scenario schedule and the constant success probability calculation as of to determine trends of project performance. The trend analysis regarding the increase or decrease of a success probability index based in target schedule or target budget offers the project team the opportunity of changing project strategies based on the expected future achievements calculated to the remaining of a schedule at any given point. At the same time, the mechanisms for setting targets to the project and the team offers an effective way of controlling project buffers not only for time, but also for costs.

**Keywords (no more than 5):** COST, TIME, RISK and SCOPE INTEGRATION
1. **Success Driven Project Management (SDPM)**

Success Driven Project Management is a method developed in Russia in the 90s for integrating risk, cost, scope and time. It consists of the following steps (Archibald et al., 2008):

### 1.1. Planning Stage

a) Determine the Resource Critical Path (RCP)
b) Calculate finish date & costs with the required probability of their successful achievement
c) Set target dates, costs & other restrictions"

### 1.2. Execution and Control

d) Calculate current probabilities of achieving goals
e) Track success probability trends
f) Manage contingency reserves"

After some definitions applied to SDPM in section 2, these steps (A to F) will be detailed in section 3 with the corresponding figures and tables.

2. **Definitions applied to SDPM**

2.1. **Cost and Schedule Integration**

Project model shall include everything that is needed for proper management, from resources to funding restrictions and other modelling elements presented within these definitions.

Most project management software packages use activity duration and cost as initial and independent information but this would not be the best modelling approach. Project schedule may depend on funding restrictions and project success criteria depend on the project cost that usually increases with the project duration.

For most projects true cost and schedule integration is possible only if to plan and control amounts of work to be done. These amounts or volumes are usually measured in some physical units (like meters, tons, pieces). Most norms and estimates refer to the units of volume of certain activity types, resource productivity is measured as activity volume per work hour. Therefore, once activity volumes for calculating both project schedule and project budget cost are used, it is possible to achieve a true cost/schedule integration.

Project cost consists of cost components like labour cost, material cost, machinery cost, indirect cost, etc. For proper cost management it shall be structured.
For right schedule and cost integration and management not only costs but also activities and resources shall be classified. Activities (resources) belong to the same type if they share their characteristics like unit cost, material requirements per volume unit, productivity on certain type of work, etc. In large projects many activities belong to the same types and it makes sense to create and to use databases or reference-books with the norms that can be applied to typical activities of any project in the organization. These reference-books are used not only for planning, changing or adjusting norms in the reference-books all future activities in projects linked with corresponding reference-books can also be updated.

- Activity costs may be defined as fixed, cost per volume unit, and cost per work hour.
- Renewable resource (people, machines) cost may be defined only as the cost per hour.
- Consumable resource (material) cost may be defined as the cost per unit.
- It is also necessary to set Assignment cost (absent in most project management packages) that also may be fixed, or defined as the cost per work unit and hour.
- Indirect costs usually depend on project (project phase) duration and are assigned on Level of Effort or Hammock activities (see 2.10 for details on hammocks). Usually dates of start and/or finish of hammock activities depend on other project activity execution and may change during project life cycle.

2.2 RCP – the Resource Critical Path.

Resources are materials, equipment, people and money. They are assigned to project activities and define constraints to the project that may alter the critical path. The application of resource levelling mechanisms will constitute the Resource Critical Path and it is calculated in both forward and backward passes.

A resource critical path generally differs from a traditional activity critical path (calculated based in CPM – Critical Path Method), as illustrated below. A resource constrained schedule as shown in this paper is calculated taking into account resource, funding, space and material supply constraints.

Figure 1. An Activity Critical Path and the histogram with resource overload.
Figure 1 Shows a simple four-task schedule that uses two resources (Resource A to tasks 1 and task 3; Resource B to tasks 2 and task4). The schedule is created using the Critical Path Method and therefore the resource histogram for Resource A and Resource B demonstrates that there are resource overloads (the red part of the histogram shows days in which the necessary quantity of resources is higher than the quantity available; the blue part of the histogram shows the days in which the resource is applied to a task and the work is compatible to the resource quantity).

In the Gantt view of figure 1, the red activities are called critical activities and such critical path is calculated solely based in the activity network logic. The activities in green are those that do not belong to the critical path.

Figure 2. A Resource Critical Path and the histogram with resource levelling

In the Gantt view of Figure 2 calculated based in the resource critical path (the schedule is constrained to the resources and the activities are altered in their sequencing both based on the activity logic and also based on the resource levelling). There is a dotted line between activity 3 and activity 1 that shows a task dependency not based on the network logic, but based on the resource constraints. the resource constraints.

The resource histogram for the schedule in Figure 2 also demonstrates that there are no resource overloads, as the activities were postponed to a certain schedule that generates no overloads.

2.3. Fragnets

A “fragnet” represents “a fragment of a network” and fragnets can be seen as building blocks for developing the schedule, while assisting the development of the WBS.

One example for use in construction projects would be a “site preparation fragnet” in which the WBS and tasks are already defined by the organization and stored in a fragnet library.

When detailing the scope, the project team does not need to develop a full WBS (Work Breakdown Structure) for the new project, but may use these building blocks during the process of breaking the project into smaller parts. A fragnet has some volumes, durations and resources stored in the library as a “standard” set of values, but the team may adjust some of its parameters that will influence the total calcula-
tion of cost and time.

An example of a simple “site preparation fragnet” is shown in figure 3.

**Figure 3.** A small fragnet for a site preparation for a construction project

2.4. Scope Definition

Scope is defined with the use of systematic Work Breakdown Structures, not limited to a single decomposition. Some of the WBS that are developed are: Resource Work Breakdown Structure; Cost Work Breakdown Structure; Product Work Breakdown Structure; Process Work Breakdown Structure; Responsibility Breakdown Structure

When developing a main WBS, which will then constitute the official schedule for most of the users, it is usual to apply successive decompositions based in a product view, as shown in figure 4.

**Figure 4.** A Product WBS for Scope Definition

However, SDPM promotes strong use of reference-books, which can be represented by tables of information regarding types of products and their attributes, list of resources and their attributes, cost centres, types of tasks and estimated productivity per resources and other information that are standardized and applied to all projects with the means of improving project estimates and portfolio controls. The use of these reference-books may constitute a set of corporative norms and/or constitute a Corporative Library of assets that are used for the development of the schedule and budget of the project.

“Fragnets” also constitute part of the Corporative Library. The use of “fragnets” in a Corporative Library
will be comprised of other WBS and tasks previously built, that will assist in the scope definition, scheduling calculation and cost estimation. Each “fragnet” depends of other assets of the Corporate Library as it is updated in values (durations, productivities, costs, quantities) based in the other tables.

Therefore, the WBS is developed using decompositions but also with bottom-up estimates, as each “fragnet” is comprised of a WBS “work package” holding other work packages and tasks, with the definition of materials, human resources, equipment, costs, volumes of work and time estimates.

Once the main WBS is built and tasks are defined for the work packages, the scope may be refined with each new WBS view (each view constitutes one of multiple WBS in a project).

2.5. Development of Multiple WBS

The main WBS of a project is built with successive decompositions of the work, as described in 2.4 – Scope Definition. However, other WBS will assist the development of the schedule for the purpose of assisting the planning, execution and control.

A new WBS view is created based in task attributes and this gives the project team a new perspective and understanding of the work, which may promote further decompositions and help clarifying the scope, resource usage and costs.

An example of a new WBS view is shown below where the attribute “responsibility” is used to transform a Product WBS into a Responsibility WBS. The same activities are seen in both WBS, but the phases and work packages will be different. Usually the first WBS of a project is product oriented and built from successive decompositions, but other WBS may be built from a bottom-up aggregation based on activity attributes (such as area, geographic, responsibilities, priorities, departments, phases and other attributes).

Original WBS – Product oriented and developed based in decompositions.

1. **PRODUCT WBS (partial)**

   1.1. **DELIVERY A**

      1.1.2. Design Engineering for Delivery A (Engineering)
      1.1.3. Manufacture Equipment for Delivery A (Manufacture)
      1.1.4. Deliver Equipment A at Construction Site (Logistics)
      1.1.5. Erect Equipment for Delivery A at Site (Construction)

   1.2. **DELIVERY B**

      1.2.1. Design Engineering for Delivery B (Engineering)
      1.2.2. Manufacture Equipment for Delivery B (Manufacture)
      1.2.3. Deliver Equipment B at Construction Site (Logistics)
1.2.4. Erect Equipment for Delivery B at Site (Construction)

New WSB – Responsibility oriented and developed from bottom-up grouping

1. RESPONSIBILITY WBS (for the tasks from Product WBS)
   1.1. ENGINEERING
      1.1.2. Design Engineering for Delivery A
      1.1.3. Design Engineering for Delivery B
   1.2. MANUFACTURE
      1.2.1. Manufacture Equipment for Delivery A
      1.2.2. Manufacture Equipment for Delivery B
   1.3. LOGISTICS
      1.3.1. Deliver Equipment A at Construction Site
      1.3.2. Deliver Equipment B at Construction Site
   1.4. CONSTRUCTION
      1.4.1. Erect Equipment for Delivery A at Site
      1.4.2. Erect Equipment for Delivery B at Site

In general terms, the new WBS represents a regrouping of tasks based on task attributes. However, parts of each new WBS constitute new “fragnets” that are detailed and verified by the project team and may constitute a complete new schedule for some of the people involved in the project.

As an example, the factory that is responsible for manufacturing Equipment A and B may never see the individual project schedule for this particular project, but its own manufacturing schedule will be built with requirements for these equipments organized with many other equipments that would be manufactured for other projects. The use of multiple-WBS will – therefore – assist a more adequate work distribution among areas and subcontractors for the organization of a company’s portfolio.

1.5. Network planning

The development of a network plan for the tasks in the project to be executed based on a main WBS decomposition but it will be developed while interacting with new WBS views and with the use of “fragnets” that will establish some sets of tasks relationships that will be complemented or adjusted to other “fragnets” when building the schedule.

An interaction over a main WBS, the use of “fragnets”, task definitions and the use of other WBS is illustrated below.

In other words, the network planning is executed during Scope Definition and it will mostly define the
critical path of the activities that later will influence the construction of a resource critical path.

1.6. Activity Durations Calculation

SDPM will promote the calculation of activity durations based in volume of work / production rate, in such form that duration is dynamically calculated based in the resource availability, the work to be performed, the priorities and the constraints.

This means that certain activities of the schedule will not have the duration estimated by the planner during scheduling estimating, but instead the volume of work will be specified and possible resources with their production rate for such work will be planned for the activities. When the schedule is calculated, the available resources and their quantities, based in their productivity and the total volume of work to be performed will determine the total duration of the task, as described in the scenarios below.

A) **Scenario 1 – 2 days**

  Work to be performed: Manufacture 6,000 units of “item A”; Resource applied: Machine A, which produces 500 units per hour; Calendar of work applied: 6 hour-shift.
  
  - Task Duration = Total Work / (Work hours per day x Resource Productivity)
  - Task Duration = 6,000 / (6 x 500) = 2 days (two days)

**Scenario 2 – 3 days**

Work to be performed: Manufacture 6,000 units of “item A”; Resource applied: Machine B, which produces 400 units per hour; Calendar of work applied: 5 hour-shift.

- Task Duration = Total Work / (Work hours per day x Resource Productivity)
- Task Duration = 6,000 / (5 x 400) = 3 days (three days)

Scenarios of available resources, expected production rates, and work to be executed will assist the construction of risk scenarios that will influence the total duration of the project, explained in Step 7 – Risk & Uncertainties Simulated.

1.7. True Critical Path Calculation

As shown in 2.2, the total duration and end date of a project may be influenced not only based in the activity network logic (Critical Path Method or CPM), but also based in the resource constraints (Resource Critical Path or RCP).

The “True Critical Path” calculated is the resulting schedule for:

- Logic & schedule constraints (CPM)
- Resource, financial & supply limitations (RCP).
1.8. Cost Calculation

SDPM promotes the development of multiple scenarios for time and cost calculation (optimistic, pessimistic and most probable), but for each scenario the cost calculation is based in a series of integrated relationship of:

I. Activities in the network
II. Resources applied to the activities
III. Durations influenced by the resources applied (based on volume of work)
IV. Actual logic (time and cost may be influenced by “what-if” scenarios built with triggers or switches and the use of corporate libraries)

Usually costs are developed based on values set for the resources (cost of people, machinery, equipment, materials and even the cost of money based in financial needs, exchange rates of currencies and the total duration of the project).

Costs may be applied to tasks directly, usually representing a fixed cost or some cost variable based in the duration of the task. For this modelling scenario, the use of “hammock” activities are helpful in determining variable cost in time, based in an original fixed value.

1.9 Hammocks

A “hammock” is a task that will be extended based in the logic of several other tasks that are linked to its start (start-to-start logic) and its end (finish-to-finish logic), so it plays the role of a “summary task” but it is influenced by tasks from one or more work packages across a schedule, as illustrated in the figure below (orange coloured task).

Figure 5. A “hammock” shown in orange, with duration defined by the remaining activities linked
For the “fragnet” illustrated above, the task “Site Operations” will increase in duration based in any delays to the tasks that are logically connected to “authorization for site construction” and “basic structured concluded”. Therefore, if a “per day fixed cost” is applied to that particular task, the cost calculation will be automatically influenced by any changes in resources, materials or productivities defined in the remaining tasks.

The “hammock” can also calculate the cost of unused resources in the other tasks. For this particular cost modelling, the same resources that are attributed to the remainder of the schedule are applied to this particular “hammock” with a “variable quantity and workload”. As a result, for each moment the resource is not applied to a specific task, its cost will be attributed as part of the cost of “Site Operations”. The following illustration shows the cost of resources “workers” split in “Site Operations” and “Site Construction”. The histogram in green shows the cost per day for the “workers” when they are not applied to any specific task, so the daily cost is attributed to “Site Operations”. The histogram in blue shows the cost per day of the same resources once they are mobilized for the tasks included in the work package “Site Construction”.

**Figure 6.** Variable quantity and workload permits the calculation of the cost of resources not performing actual work with the use of “hammock activities”.

### 1.10. Cost elements

Cost in any activity is driven by “the 7Ms”: Method, Measurement, Milieu, Machinery, Material, Manpower and MONEY.

- **Method**, which is the task in itself, will determine production rules that will influence the resource usage. When building a probabilistic schedule, some tasks may influence the total cost and duration of a particular scenario but not the other (in other words, in a pessimistic scenario costs and durations for a particular set of tasks may be different from an optimistic scenario and – if switches are used – a series of tasks may exist to determine the duration and cost of an optimistic scenario, but
for the pessimistic scenario another series of tasks that may constitute that particular scenario).

- **Measurement** will influence the actual updates of cost and duration to a task. An initial scenario may expect a certain quantity of materials or a specific productivity of the team and the actual measurement of task progress will influence the duration and cost calculation for the remainder of the project during preplanning. Actual values may alter the Corporative Library and be used to update expected values to other tasks in the project, thus influencing the entire network of activities.

- **Milieu** is the physical or social settings in which tasks will be performed and changes in expected conditions will influence future cost and duration calculations.

- **Machinery** is the total quantity of machinery attributed to a task and its related cost and productivity. For volume driven tasks, the change of a particular machine for another will represent a change in the expected productivity and therefore will influence changes in the duration and cost of a task. In probabilistic scenarios, the cost or duration of a task may be determined by the use of a high cost/low productivity machine for a pessimistic scenario and a low cost/high productivity machine for an optimistic scenario, for example.

- **Materials** are resources that may be produced or consumed by a task. It differs from Machinery or Manpower as they are consumed during activity performance and if consumed to its limit will force a task to stop until such materials are produced by other tasks (a purchase order activity or a production activity may determine the increase of the material stock). In “True Critical Path”, the lack of the necessary material will determine delays in tasks until replacement of a stock. If not fully resource levelled, a schedule not based in material shortage may demonstrate the consumption of the material above the available stock.

- **Manpower** would have a behaviour similar to machinery in tasks. To some detail scheduling model, it is possible to attribute specific manpower to specific machinery in such way that manpower working hours, shifts and individual calendars may influence the usage of the machinery related to such manpower.

- **MONEY** may be seen as a special type of material, as it is also “produced” (set of tasks may determine payments for the project that correspond to the increase of money stocked to the project) and “consumed” (the cost of each task will consume the stock of money). Advance cost and scheduling model would include multiple currencies and the calculation of the cost of the use of money, as from the need of financing the budget of a project from a bank or the change in currency exchange rates.

In the following figures, total cost of Site Preparation is formed by the bottom-up values encountered in all tasks associated to its parent task. In the example, the task related to the mobilization of an office container is constituted by the total cost of manpower (worker) and the cost of machinery (computer) as seen in figure 7. However, other costs – such as of consumable materials – are indirectly associated to that particular task and is shown in figure 8, which illustrates the use of a “Material Gantt Diagram”.


In Figure 7, “Office Containers” has a total cost of 820 units. This value is calculated from 600 units of Worker and 80 units of Computer (also from Figure 7) and other 140 units shown in Figure 8 (100 units of Water and 40 units of Electricity).

Costs may be calculated as a fixed value to a task or a resource, or as a variable value calculated by volume units or per hour. The total cost of an activity is affected by the costs attributed directly to the task plus the costs defined for the resources (manpower and machinery) and then the cost of consumable material.

1.11. Three-point estimates

The examples below are illustrated based in the use of a Beta distribution of probabilities to a task (figure 9). While other distributions may be used, the concepts needed for the understanding of buffers and success probabilities with the application of SDPM are the same.

Once the project schedule is built, the initial estimates are developed using three-point estimations, with the following rules for estimating:
In the optimistic scenario:

- Task durations, volumes of work, number of resources, material needs, costs per unit or per volume and other values for the project are registered in the schedule with an estimate that is considered to be valid for at least five of every one hundred cases. Accordingly, it is said that the estimated value will happen in at least 5% of the cases.

In the most probable scenario:

- Task durations, volumes of work, number of resources, material needs, costs per unit or per volume and other values for the project are registered in the schedule with an estimate that is considered to be valid for at least half of every one hundred cases. Accordingly, it is said that the estimated value will happen in at least 50% of the cases.

In the pessimist scenario:

- Task durations, volumes of work, number of resources, material needs, costs per unit or per volume and other values for the project are registered in the schedule with an estimate that is considered to be valid for at least ninety-five of every one hundred cases. Accordingly, it is said that the estimated value will happen in at least 95% of the cases.

1.12. Probabilistic Scheduling

With the application of Monte Carlo Simulation (many algorithms and applications available) or the use of Liberzon Curve (a proprietary algorithm of scheduling available in Russian Software Spider Project), a probabilistic schedule is the resulting estimates for the sum of project tasks based on the three-scenarios built (optimistic, most probable and pessimistic scenarios), as shown in figure 10.

![Figure 10. A Monte Carlo simulation based in three estimates per task](image)

The application of simulations will have, as a result, a series of estimates for the entire project, developed from the individual estimates of each task in each of the three scenarios.

These probabilistic estimates may be calculated for the total duration, use of materials, total cost, resource usage or other values modelled in the schedule with pessimistic, optimistic or most probable.
With the simulation, it is possible to calculate a certain situation for the project (a combination of resources, materials, durations, volume of work and costs) for a chosen probability of success (figure 11).

**Figure 11.** A chosen probabilistic scenario (X%) based in the risk simulation

The “X%” is the success probability chosen by the project team for determining the target schedule and budget. The higher the level of probability of success that is desired for a project, the closer the target schedule will be to a pessimistic scenario.

- The higher probability of success for project total duration that is set as target, the closer the schedule will have its duration based on the pessimistic scenario.
- The higher probability of success for project total cost that is set as a target, the closer the schedule will have its cost based on the pessimistic scenario.

### 1.13. Target Schedule and Project Buffers

The use of a Monte Carlo Simulation without the application of Success Driven Project Management may generate a target schedule and budget that will be used as the project schedule for its execution and control.

However, when applying SDPM, the team will use an optimistic or most probable scenario as the “Project Team Schedule” and it will control the deviations and management decisions based in the comparative view of the target schedule and the project team schedule.

A “Project Buffer” is then calculated as the difference of total duration and budget from the Target Schedule to the Project Team Schedule.

**Example:**

A given project has three scenarios built with a total duration of 50/80/140 days (optimistic/most probable/pessimistic) and running a Monte Carlo Simulation it was calculated that with a 70% success probability the total duration of the project would be 100 days.

- A schedule with 100 days is called “target schedule”.
- If the team is given the instruction to apply the most probable schedule (with 80 days), the difference in duration from 100 to 80 days is the project buffer for duration.
The same applies to any other values calculated with the three scenarios, from material consumption to total project budget.

1.14. Contingency Reserves

Any buffer calculated based in the target schedule (for cost, duration, material or resource usage) is called a contingency reserve.

1.15. Accuracy x Precision

Accuracy is accomplished when using a Monte Carlo Simulation and therefore the expected result should be very near the true value if measuring the future would be possible. If the “real total duration” of a project would be of 100 days, a Monte Carlo Simulation could generate, as possible results, a total duration of 96, 98, 102 days, for example.

Precision is accomplished when using the Liberzon Curve and the expected result would be close to the true value. While not “as close” as the results obtained with Monte Carlo, the result would be always the same with the same given initial data. If the “real total duration” of a project would be of 100 days, a Liberzon Curve calculation could generate as possible results a total duration of 92 days, for example.

For the application of SDPM, one may prefer developing its control based in a more accurate or more precise estimation. The difference from both are shown in the following figure.

Figure 12. A perspective view of the difference from Accuracy to Precision
- **Accuracy** – A series of numbers that are "close to the real value", but will be different at each Monte Carlo Simulation.

- **Precision** – A single number that is somehow "close to the real value", but it will be maintained forever while the original conditions for the calculation remains the same.

### 1.16. Success probability trends

Once a Target schedule/budget is set, during project execution and control, as activities are completed, it is constantly recalculated to determine the success probability for the original Target. The series of values calculated will offer high management and the project team the evaluation of trends regarding the approximation or distance from original target to a certain present situation.

**A)** After initial plan, a probabilistic schedule is built, with an agreed probability of success.

**B)** After any changes in project scheduling, a new probability of achieving the targets agreed is calculated.

**C)** The historic data of success probabilities calculated will generate trends regarding the condition of the project to meet its target plan.

**Example:**

**A) During Project Plan**

A given project has three scenarios built with a total duration of 50/80/140 days (optimistic/most probable/pessimistic) and running a Monte Carlo Simulation it was calculated that with a 70% success probability the total duration of the project would be of 100 days.

- A schedule with 100 days is called “target schedule”.

**B) During Project Execution and Control**

The success probability for a total duration of the project of 100 days (target schedule) is calculated for the remainder of the project. Only tasks and resources not yet measured are used in the new success probability calculation, so the remainder of the project is calculated against fulfilling its original target, considering that there is a reduced number of days for the project based in the present date.

It may occur that due to actual progress measured to the date and the actual conditions to conclude the project, the probability of success may decrease or increase for the remainder of the project.

If supposedly the probability of success for the given project was at 70% on the starting date, at 65% as of 15 days from its start, 60% as of 30 days from its start, there is a clear trend of not fulfilling the target total duration of 100 days as the probability of achieving such result is being reduced at each fifteen days.
1.17. Project Cash flow within a Portfolio

There is another problem ignored by most popular project management software. Projects may have funding restrictions. Therefore, it is necessary to model the schedule of several projects into a portfolio, including financing and payments to subcontractors, workforce, materials, etc.

A portfolio cash flow will then influence the project cash flow and vice-versa. If the funding in several projects are not modelled together within the portfolio they share resources with, the actual cash flow for each individual project may not be properly scheduled.

2. Sample Project

The following project with cost and risk integrated to the schedule model demonstrates how SDPM is applied to manage the elements previously defined, into a complete method for planning, executing and controlling projects and portfolios.

Examples for each step described on section 1, for the Planning Stage and Execution and Control will be shown in the next figures.

SDPM steps are defined from (A) to (F), where A,B and C are steps during the Planning Stage and D,E,F are steps for Execution and Control Stages.

2.1 Planning Stage

A) Determine the Resource Critical Path (RCP)

For such step, traditional CPM (Critical Path Method) scheduling modelling is used, with the assistance of multiple WBS, fragnets and other elements of a corporative library explained in the previous section. Initial sample project is shown below. Phase 2 details are not shown, but they hold the same tasks and resource usage as Phase 1.
◊ Initial cost is calculated by defining cost per hour for each resource;

◊ Sample cost of material usage is determined by a fixed quantity to task “Office Containers”, with the consumption of water and electricity.

Figure 13. Sample Project - Part 1 - Only CPM calculation

Figure 14. Sample use of materials with cost of 1 unit per unit of material

◊ Resources were distributed to some tasks, as seen in the following resource Gantt (figure 15).
• Standard Resource Levelling: Using basic algorithm similar to what is seen in most schedule packages that execute some type of levelling, the total duration of this sample project is 80 days (figure 16).

**Figure 16.** Sample project with resource levelling (main work packages) with a total duration of 80 days and a total cost of 32700 units

• Optimized Resource Levelling: Using proprietary algorithm of the software package used (Spider Project), the total duration of this project is 75 days.

**Figure 17.** Sample project with resource levelling (main work packages) of a total duration of 75 days and a total cost of 30480 units

When a schedule is calculated using only activity logic, as in the Critical Path Method, it is expected that all scheduling packages will deliver the same end date, as such path can be mathematically calculated.

For the execution of a resource levelling mechanism, it is necessary the use of algorithms and there is no mathematic answer that will guarantee the results. Therefore, each software package may deliver one or
more results to any number of resource levelling requirements.

For the purpose of this schedule model a task of the type “hammock” represents fixed costs per day in a project. Once the same activity network and resource restrictions are calculated using different algorithms, the total cost for schedule in figure 19 is 32700 cost units and the total cost for schedule in figure 20 is 30480 units, or a 7% total cost reduction by means only of the use of different scheduling algorithms.

B) Calculate finish date & costs with the required probability of their successful achievement

For SDPM, it is favourable to use a three-point estimate with the construction of three different schedule scenarios. A single schedule with three-point estimate and the use a Monte Carlo Simulation may also be used. For the following example, SDPM is calculated with the use of Liberzon Curve, a proprietary algorithm present in the software package used.

To build a simple exercise, the schedule shown in Figure 20 is the “Most Probable Scenario”. For the construction of the “Optimistic Scenario”, all tasks with duration of 10 days were reduced to 8 days and all tasks of duration of 5 days were reduced to 3 in Phase 1 and to 4 in Phase 2 of the project.

The resulting optimistic scenario is shown in figure 18, with a total optimistic duration of 63 days and an optimistic budget of 25488 cost units.

**Figure 18.** Sample optimistic scenario with a total duration of 63 days and cost of 25488 units

In order to focus in the method, not the quality of the information used, the pessimistic scenario is also built with some sample data modification applied to the most probable scenario.

The changes applied were: All tasks of 10 days from Phase 1 of the project will take 15 days; all tasks of 10 days from Phase 2 will take 12 days. The pessimistic scenario is shown in figure 19.

The new duration is of 89 days and total cost of 36732 units.
Figure 19. Sample Pessimistic Scenario with a total duration of 89 days and cost of 36732 units.

More realistic schedule scenarios can be built with the use of many schedule elements, such as the expected increase in production for some types of resources, changes in calendars (favouring, for example longer days due to lack of rain), the arrival of complementary resources, alternative paths in a what-if-scenario and several other modelling adjustments.

In figures 18 and 19, the numbers shown in the Gantt View represent the total duration that was reduced (-12 days in the optimistic scenario when compared to most probable) or increased (+22 days in the pessimistic scenario when compared to most probable). Each individual task may have a different reduction or increase when compared to the most probable scenario (shown in salmon colour in each scenario).

The following figure integrates the three scenarios. In SALMON: Optimistic Scenario; In grey/Red/Green: The Most Probable Scenario; In Light Grey: The Pessimistic Scenario, with values for Duration (Optimistic, Most Probable and Pessimistic) and Cost (Optimistic, Most Probable and Pessimistic).
Partial data for this project is shown in table 1. For a select group of activities, it is possible to verify the optimistic, most probable and pessimistic duration and cost used for the scenarios built.

**Table 1. Optimistic, Most Probable and Pessimistic Duration/Cost for Sample Project.**
C) **Set target dates, costs & other restrictions**

An illustrative view of the three scenarios for both total duration and cost is seen in figure 21 and figure 22 with a sample representation of a Beta Curve for such scenarios.

**Figure 21.** Simple representation of three-scenarios for DURATION UNITS

![Figure 21](image)

**Figure 22.** Simple representation of three-scenarios for COST UNITS

![Figure 22](image)

D) **Results calculated by the Liberzon Curve**

Using proprietary algorithm for the Liberzon Curve, the calculated success probability of completing the project with a total duration of 75 days is of 46.8% and with a total cost of 30480 units of 45.1%

**Figure 23.** Success Probability for Duration and Cost calculated using the Liberzon Curve

![Figure 23](image)
E) **Results calculated by using a Monte Carlo Simulation**

Monte Carlo Simulation is of a higher accuracy, but for each time a new simulation is executed, a new result is produced. Running 1000 interactions for a 46.8% success probability, the total duration of the project would be of 75.88 days instead of the 75 days calculated by the Liberzon Curve.

![Figure 24. Success Probability for Duration and Cost calculated using Monte Carlo](image)

The first 1000 interactions for a 45.1% success probability, the total cost of the project would be of 30899 units instead of the 30480 units calculated by the Liberzon Curve

F) **The importance of precision**

By running a second set of 1000 interactions for a 45.1% success probability, the total cost of the project changes from 30899 to 30929 units. If a project is to be managed by trends of success probability, but for the same target duration or target cost the probability changes as a result of the random process in which Monte Carlo is executed, the manager and project team may consider they are improving their success probability at some point due to some higher productivity or management decision but the result was – in fact – achieved solely because of the random condition found in the use of Monte Carlo.

Therefore, SDPM will promote the use of estimates of higher precision and lower accuracy. They may be achieved by simple methods such as a PERT calculation or with the use of the Liberzon Curve.

G) **Setting Project Targets**

For an illustration of how trends and buffering is used in SDPM, the sample project is set to a target duration with a 75% probability of success and a target cost also with a 75% probability of success.

H) **Setting Team Targets**

It is suggested that for teams that have been using the method, the target schedule for the team is the optimistic scenario, creating a very challenging goal for the team. For the initial application of the method, the use of a most probable scenario is suggested.

I) **Calculating Buffers**
Using the most probable scenario as the team schedule, the necessary buffer for a 75% probability of success in guaranteeing the total cost is equal to 1560 units. This is calculated by subtracting the total cost at 75% of probability of success from total cost of the most probable scenario, as illustrated in Figure 28.

![Figure 28 - Calculating the Cost Buffer](image)

Using the same procedure, 78.42 days is the expected total duration for a success probability of 75% and therefore the duration buffer for this small project is of 3.42 days (3.5%).

### 2.2. Execution and Control

**A) Calculate current probabilities of achieving goals**

During project execution and control, the team will repeat the calculation of the success probability of achieving the total duration of 78.42 days and 32040 units of cost from time to time. The calculation will take in consideration the remainder of the project, not the activities already performed.

If a current probability to a given week is lower than the goal, an immediate change of strategy for the project is required. Therefore, by calculating the current probabilities for the same goals, the team will keep track of their buffer of cost and duration.

**B) Track success probability trends**

Success Probability results must be recorded and therefore the historic changes to each index (cost or duration or any other target set using the same mechanism) may be tracked within a trend analysis.

At every project performance evaluation, the success probability index for each variable can be calculated, as seen in the next figure. Table 2 shows the Success probability index of cost for each date it was measured. This data is used to create the trends from the following illustration (lower graph in figure 26).
Table 2. Calculated Success Probability Index for keeping the target cost of 32040 Units

<table>
<thead>
<tr>
<th>Name</th>
<th>15/02/2016</th>
<th>23/02/2016</th>
<th>08/03/2016</th>
<th>15/03/2016</th>
<th>22/03/2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICEC 2016 (Project)</td>
<td>74.98</td>
<td>61.11</td>
<td>52.83</td>
<td>66.67</td>
<td>77.06</td>
</tr>
</tbody>
</table>

The following figures demonstrate the evolution of the Success Probability Index for COST for a series of project execution reports (progress measured). In figure 26, the dotted line between the red and orange arrows is the “status date” and separates in the schedule all the tasks that were executed from the remaining tasks that are planned to be executed.

**Figure 26.** Success Probability Index for COST (bottom graph) and schedule after partial execution.

C) **Manage contingency reserves**

Cost and Duration contingency can be calculated at any given time. The Figure below shows a series of moments in which the project was monitored and the probability of succeeding with the target cost was evaluated using the success probability index for the remainder of the schedule.

From figure 27, it is possible to verify that on the week of March 7th, the results of the project were not as good as expected and the success probability was down from 77% to 52.83% which applied to the buffer calculation indicates a buffer of cost of only 359 units. In the following weeks, the project is recuperated and again there is an expected success probability index of 77.06%, representing a total cost buffer of 1869.42 units.
3. Conclusions

As it has been illustrated before, management by trends can be executed using more accurate methods (Monte Carlo Simulation) or more precise methods (PERT, Liberzon Curve). The steps described for SDPM will promote the integration of scope, cost, time and risk analysis into one single mechanism for trend calculation and its application in project planning and control.

While SDPM can be used with both Monte Carlo Simulation or three-point estimates, it is important to give emphasis to a management concept of SDPM related to acting according to trends (more active management involvement when the success probability index is lowering from one week to another, denoting the reduction of time/cost buffers and more of autonomy to keep the performance given to the team when the success probability index is increasing from one week to another.

When using Monte Carlo, it is important to remember that a Success Probability Index may be reduced or increased from one week to another not because of a lower or greater performance of the project team, but simply because of the random aspect of how it is built.

It is interesting – however – to point out that management decisions are taken based in to what direction the Success Probability Index is moving, independently of the actual number it represents. In this context, the precision of the Liberzon Curve is of more useful than the use of Monte Carlo Simulation and its accuracy.

As it can be seen in Figures 28 and 29, management decisions can be taken in both scenarios, having access or not to accurate numbers. The first figure shows the trends with the assistance of an accurate number. The second figure shows trends without a specific number, representing that decisions can be taken by the direction to where the probability index is pointing, regardless of the actual number calculated by a given method.

Figure 27. Contingency reserves calculated from Success Probability Index (low of 52.83% and high of 77.08%)
Figure 28. Management decisions based in Success Probability Trends may depend on accurate calculation.

Figure 29. Management decisions may be based in trends even when accurate numbers are not available.

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Comparative analysis between the application finishing manual and mechanical external with cement mortar: a case study in a construction site located in Feira de Santana.

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ABSTRACT

Optimization and rationalization concepts on construction sites with the aim to integrate the various sectors are increasingly expected of the new civil engineers. This research article was conducted in order to find the best alternative among the construction methods of manual and mechanized outer covering. Data was collected through consultation to the regulations, area publications, market research and field visits, later taking the costs for each type, displayed in the tables of this research. During the analysis, one standard of calculation of cost by constructive unit was adopted to facilitate understanding, finding a cost difference between the techniques analyzed by square meter and the number of days for performing of the building type that has ground-level and four floors resulting in the perception that the mechanized application is more advantageous both terms of in execution time and in the final cost.

Keywords: Mortar; exterior cladding; Mechanization

1 INTRODUCTION

Increasingly common in civil construction, concepts such as optimization, rationalization and industrialization are being rapidly disseminated, making feasible the introduction of new building technologies. These innovations have allowed more and more that the projects become more productive, resulting in better results for builders.
At the construction site, an example of rationalization and industrialization is the outer covering with mechanized mortar. This technique is to coat the seals mechanically, so that a reduction of labor occurs, accelerating productivity, thereby reducing the service completion times.

The mortar projection technology has been adopted as the object of analysis because it is a constructive method that it is inserted in the current context of the Construction Industry of Feira de Santana. Due to the shortage of skilled labor, Paravisi (2008) states that it is common that this step represents the bottleneck of production and without this necessary resource, the consequences would be reflected in the implementation period. The insertion of mechanized technique has as main objective to reduce the time and the amount of employees involved in the activity to step into the study.

In general the objective is to compare the manual and mechanized coating methods of execution of a construction site (in a housing estate located in Feira de Santana) in the year 2014.

Specifically it has as objective to identify labor costs and supplies involved in coating activities with cement mortar with manual application and mechanized application relating to the case study analysis, generating indexes, costs and graphics that will be used as parameters for the conclusion of the article.

In front of the context justified this research project as an alternative to improve coating activity traditionally applied manually, since coat facades manually has become often an obstacle for companies to comply with the terms determined by the chronogram.

2 RESEARCH METHODOLOGY

2.1 METHODS

Anderson Correa apud Dmitruk (2004) points out that at the time of planning must be submitted to the nature or type of research, selected sources, the research universe and technical resources for the collection and analysis of data collected.

Gil (2002) states that the classification of objectives-based research are: exploratory research, descriptive and explanatory. This article is classified in relation to the objective of exploratory nature, in which your goal is to provide greater familiarity with the problem, in order to make it more explicit or making hypotheses, generating improvement ideas or discovering insights and descriptive, since its main objective is the establishment of relationship between variables and description of the characteristics of a given population or phenomenon, the outer covering.

The classification of research based on used technical procedures is important, since in order to occur an analysis of the facts from empirical point of view, there must be a confrontation between the theoretical view with the data of reality, making it extremely necessary for a model conceptual and operational research (Gil, 2002). The delineation is the most appropriate term to use, as it is the research planning in its widest dimension performing correlations between the layout, the forecast analysis and interpretation of data collection. The delineations groups are classified into two groups, the first refers to research
that is based on materials already prepared, as bibliographic research and documentary research, and the second is done using data provided by people such as experimental research, research ex post facto, the survey and the case study (GIL, 2002). This article was chosen based on Yin (2001), in which the search strategy is the Case Study, to be an analysis of real contexts of different executions with a view to understanding a phenomenon or functional organization.

The case studies can be classified as to the evaluations into: quantitative and qualitative assessments, this article discusses according to qualitative assessments, since according to Martins (2008 p.xi) this article:

It is an empirical research that research phenomena within its real context (naturalistic research) where the researcher has no control over events and variables, seeking to learn the totality of a situation and creatively describe, understand and interpret the complexity of a specific case.

This research was organized in two phases: The bibliographic research and field research. The first phase, the bibliographical research, exploratory character, the literature sources were books, theses, articles, journals, conference publications, manuals and websites. The second phase, field research, exploratory and descriptive character, seeking to exploit the two phenomena in greater depth, providing greater familiarity with the situation in order to make it explicit, so helping to identify variables as identifying the problems yet they are known, where will occur a cost analysis respectively so that each type is analyzed and evaluated in a comparative study with the aim to find the most viable solution to the construction site under study.

<table>
<thead>
<tr>
<th>Phases of the research</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A Bibliographic Review</td>
</tr>
<tr>
<td>A Visit to the construction site</td>
</tr>
<tr>
<td>Observe and collection of data from the exterior cladding of production methods with mechanical application and mortar Manual</td>
</tr>
<tr>
<td>C Analysis of the data and review of the methods used</td>
</tr>
<tr>
<td>D Finalization of the data and conclusions</td>
</tr>
</tbody>
</table>

Chart 01 - Phases of Research. Source: Prepared by the author – 2014

2.2 DELIMITATION OF STUDY

This article has as delimitation the fact that the study was conducted at the site construction X of construction company A in city of Feira de Santana, state of Bahia, in Brazil. Delimitation occurs mainly regarding the costs and productivity during the coating run.
2.3 SAMPLE

The construction site of this research object of works is carried out by the construction company A and is located in São Salvador Street, Feira VII district, city of Feira de Santana, Bahia, Brazil.

Samples were collected daily starting on March 2014 until May 2014, data were collected then in the researcher filled worksheets for each type of coating.

2.4 INSTRUMENT OF DATA COLLECTION

For a better evaluation of the same standard spreadsheets were chosen and this collection was carried out in loco, where the necessary data were obtained. Then they were gathered data on the productivity of both processes, the focus of this study.

The evaluation method of facade coating production system to manual and mechanized mortar base includes the measurement of the related costs according to the survey data during production. Various stages of production were accompanied, from the assembly of equipment and preparation of surface of facade until the execution of coating and your cleaning. The data collected allowed not only analyze better characterization of production enterprises systems, but also identify costs, advantages and disadvantages for each system, and signal opportunities for improvement.

3 CONTEXTUALIZATION OF CIVIL CONSTRUCTION INDUSTRY

The construction sector has progressed significantly in recent years, according to the Brazilian Institute of Geography and Statistics (IBGE, 2010), between 2007 and 2012, the Civil Construction Industry (CCI) had a significantly higher growth than GDP national (about 1.8 times). The National Construction Index (INCC) accumulated growth of 43.4% between 2007 and 2012, while the National Index of Consumer Prices Broad (IPCA) accumulated growth of 31.9% in the same period.

Ernst & Young (2014) states that one of the main causes of this growth has been the increase in demand mainly associated with the housing deficit, generating greater business concern with factors such as control and productivity on construction sites. Therefore, the structural factors that warrant greater focus on these aspects are associated with rising costs and their impact on the profitability of the projects; which leads companies to seek alternatives to rationalize costs and optimize / accelerate the execution of activities in order to reduce the impact of high rising production costs.

Associated with the aspects of rationalization, according to IBGE (2010) “The Added Value of Civil Construction activity showed the best result since 1995, with real growth of 7.9% in 2008 over the previous year. This result can be attributed primarily to the increase in housing loans, government infrastructure programs and public and private investment.”

Thus, the economic growth provide a favorable scenario of accelerating the Building Industry growth, which in turn seeks alternatives to optimize the execution of construction activities. On the other hand, this growth scenario, brought as reflecting a sharp increase in the cost of manpower, coupled with short-
age of professionals, which can be evidenced by the graph 01, where displaying the behavior curves of the national minimum and professional minimum wages construction compared to other economic indices.

Graph 01 - Comparison INCC X INPC X PROFESSIONAL WAGE X MINIMUM WAGE. Source: SINDUSCON / BA; FGV - Prepared by Author

So, the Civil Construction Industry lies in a favorable scenario of growth, but comes up against the lack of skilled labor and high costs associated with production. With intention of finished these difficulties the industry is making room for the use of new building technologies, reducing the demand for workers by activity.

Fonseca do Carmo Soares and Tavares (2011) state that the search for constant improvement of services and processes in civil construction, where they are less costly, faster and more sustainably is a correct posture expected of the new civil engineers. Over time, various sectors of the economy have been modernized and invested in new technologies to improve their final products. However, Anderson Correa says that “the lack of effective management in the production process, low rationalization, industrialization and dependence skill and knowledge of the operator are the production process characteristics that are still in the works” so that more and more “the integration of the construction sector is evidenced by Taniguti et al. (2005), as a key to improve the sector’s performance in quality and productivity “(PARAVISI, 2008, p.16).

In this scenario, there is a conclusion that the search for technological innovations currently has become...
a prerequisite for survival in this market. An example that illustrates this fact is the outer coating step, because it is common that it represents the moment of difficulty in accelerating the schedule due to the shortage of skilled labor and the pre concept with new technologies (SCHRAMM and Formoso, 2007).

4 MORTAR

According Carasek (2007) “Mortars are building materials with properties of adhesion and hardness, obtained from a homogeneous blend of one or more binders, fine aggregate (sand) and water and may further contain additives and mineral additions.”

According to Fiorito (2010) the objective of the mortars is regularization of surfaces, vertical or horizontal, sequenced the definition of plans where the coatings will be installed. The mortar is responsible for connecting the elements, as well as the appearance and quality of finish, whether internal or external. (AZEREDO, 2006).

The Brazilian Norm regulates 13749 (ABNT, 1996, p.2):

- Materials and their dosing proportions should be compatible with the finish and the expected exposure conditions;
- Have mechanical strength compatible with the selected decorative finish;
- When colored, the pigment used should resist the action of ultraviolet radiation and the alkalinity of the mortar.

This article discusses the use of single-layer mortar in order to externally coat verticalized buildings in a typology specifies of the building type that has ground-level and four floors. With the function, according to Carasek (2007), to protect the brickwork, and the structure against weathering, integrate the sealing system of buildings, contributing to different functions (sealing, for example), regularizing the surface of the sealing elements and serve as a basis for decorative finishes, the main properties workability (consistency, plasticity and initial adhesion), low shrinkage, adherence, low water permeability, ability to absorb deformation and mechanical strength.

Concomitantly Portuguese Association of Manufacturers Mortars Construction (APFAC, 2009) states that the mortar can be classified as traditional and industrial by the production site. Mortars of this case study are traditional who it is dosed and mixed on construction site and constituted of primary compounds as aggregates and water binders.

2.1 EXTERNAL USE MORTARS

APFAC (2009) reveals the existence of two types facade coatings: The discontinuous which comprise fixed support elements by gluing and / or mechanical fasteners, such as ventilated facades, natural
stones (marble, granite), artificial stones, pre elements manufactured or ceramic or continuous parts are applied to the masonry wall; and run by industrial mortars as plaster, monomassa or mortar used in ETICS systems (External Thermal Insulation Composite Systems). The theme of this paper discusses the continuous coatings.

Sabbatini (2004) states that the exterior cladding is characterized as “set of layers overlying the seals of a building (and structure) with the functions of protecting them against deterioration agents of action; additional sealing function and be in the final finishing, exercising aesthetic functions, economic recovery and other related use”. That is, the coating is done so that there is a weather protection, as Brites (2007) states the external coating is the most exposed part soon, that suffers most from the action of aggressive agents.

According to the Brazilian Association of Portland Cement (ABCP 2013, p 109.):

The mortar coating helps protect the masonry of water infiltration, impact and wear proven by the weather. However, its main function is to regulate the surface finish before receiving the finish, eliminating imperfections and filling gaps left in the masonry settlement.

The coating system with mortar use is widely used in Brazil, and the most used is the cement mortar, lime and sand, by to be the most economical and simple to perform. (Borges, 2009, p.197). Nevertheless, its production is characterized by high levels of loss, high variability, low productivity and product quality problems. (Paravisi, 2008).

4.1.1 APPLICATION OF FINISHING EXTERNAL OF CEMENT MORTAR

According to Borges (2009) the general application of the mortar coating is made of three layers: roughcast, plaster and mortar, but may also be comprised of two layers: roughcast and coating called single mass or paulista plaster. Thus, Bala and Sabbatini (1998) observed that in the case of two layer coatings, the function of base of regularization is of the plaster and mortar has finish function. Already in coatings that consist of a single mass, that fulfills both functions.

According Piovezan and Crescenci (2003) the traditional mortar coating applied in multiple layers, usually the “roughcast”, the “plaster” and “mortar” has undergone profound changes, to reduce production steps, increase productivity, decrease consumption of materials and therefore reduce the final cost. Thus, the single-layer coating is gaining ground in civil construction, initially applied inside buildings and, more recently, on the facades.

The Tabela de Composição de Preços de Orçamentos³ (TCPO, in 2013) makes it clear that to receive the single mass name their surface characteristics have to be consistent with the direct application of paint and when the same is not true, is called the plaster.

³In English, Chats of Composition of Prices for Budgets.
The Associação Brasileira de Cimento Portand⁴ (ABCP, 2013) states that the removal of a layer in the outer coating process causes a reduction of hand costs of work, material and time. Britez (2007) states that the possibility of using a single layer of dough, happened to more economic motivations than technical.

The Brazilian Norm 7200 (ABNT, 1998) regulates that mortar coating layer should be applied on a base (wall or nonmetallic ceiling), previously cleaned respecting the indications thereof which comprises brick substrates and ceramic block, concrete block or cellular and sandlime.

Before applying the mortar coating, should happen the preparation of the plan in which it will be applied. The first step to be executed is the coarse cleaning, implementation is done by removing material from the pieces, burrs, between masonry joints, mold, efflorescence, release agent or any other material that influences the adhesion between the base and the roughcast, and as masonry holes or any corrections concreting failures. The fine cleaning is done in specific locations in which the base is concrete, which should be made a mechanical treatment with steel brushes, grinders or discs, in order to remove the most exposed impurities, then carried out another cleaning with water and brush with steel bristles for total removal of waste loose particles still attached to the surface of concrete (COMUNIDADE DA CONSTRUÇÃO, 2012).

The second step is the roughcast, wherein the NBR 7200 (ABNT, 1998 p.6) regulates the application that “must be applied with a fluid consistency, ensuring easier penetration of the cement paste to be coated on the base and improving grip on the interface coating base and must be applied for release, with care not to completely cover the base. ”

Then it is determined reference points arranged such that the size of the ruler to be used in sarrafeamento⁵ is compatible. At these points, taliscas or pieces flat of ceramic material must be fixed, with the same mortar to be used in the coating (NBR 7200, ABNT, 1998). These taliscas should be giving preference to points of lesser thickness, depending on a distance from the facade of wires to the upright position coating (YAZAGI, 2013).

Once set the coating plane, should be made vertical fills tracks between taliscas, using mortar, composing the guides or mestras.” (NBR 7200, ABNT, 1998). That is, “the mestras are vertical guides between taliscas that serve as support for the alignment of the mortar coating.” (ABCP, 2013, p.122).

After hardening of the guides, it begins the process of regularization of the guides with the help of the clapboard, the mortar is applied onto the surface to be coated manually with a trowel or projecting, if it is mechanized process until the entire surface acquire a satisfactory thickness of this layer. Even at this stage, the taliscas should be removed and filled their spaces (YAZAGI, 2013).

With the area filled in its entirety and mortar with enough consistency, retir the excess so that there is regularizing the surface through the passage of the ruler. In places where the finish is not satisfactory, it should launch again the mortar and repeat the sarrafeamento operation until a flat and homogeneous

⁴ In English, Brasilian Association of Portland Cement.
⁵ It’s the process of regularization of the guides with the help of the clapboard.
surface (Yazagi, 2013). The NBR 13529 (ABNT, 1995) determines the mortar coating as surface coatings with one or more superimposed layers of mortar is able to receive or provide decorative finish to the final finishing.

According to Fonseca, Carmo and Tavares (2011) the mortar coatings, are still applied by hand in much of the country, but a specific machinery for this step has already been developing for a few decades, especially in Europe. In Brazil, this technology was presented only in the late twentieth century, and even with more than twenty years, it is little used.

The ABCP (2012) apud Melissa de Castro (2012), assert that the lack of skilled labor on the one hand, and the expansion of the real estate market on the other, are encouraging companies to invest in technology to increase productivity and improve the quality of projects. For the finish, the traditional application described above manually is being replaced at construction sites for equipment to design the mortar. This scenario is a reflection of the civil construction market growth, which causes an increase sharp in volume of construction works, so it have sought to absorb new construction methods that accelerate the steps of construction.

Importantly, in addition to technical of acceleration of the construction process, it is necessary to think of fronts of accelerated teams and trained to make the process happen, that is, it’s no use having a high productivity system if it isn’t equated with this high production, a specialized team ahead of services, optimizing and opening the field for external coatings. Therefore, in addition to investing in new construction techniques, it is necessary to invest in specialization of production teams, promoting the specialization of companies, not only in view of execution, but the organization tied to this execution. (CONSTRUÇÃO MERCADO, 2013)

The alternative of the author as a solution of these problems is “the mechanized mortar system industrialized, which enables companies to increase productivity and improve the quality and thus competitiveness. Another advantage is the reduction of labor costs.” (ABCP, 2012, p.1). Paravisi (2008, p. 40) states that mortar hand application for coating production can be another source of problems. One consequence proven is variability of product quality due to the variation of the application form. While the mechanized coating have not been found technical obstacles in terms of pathology, because the problems detected if more should the composition and production of mortar that the projection phase itself. (CONSTRUÇÃO MERCADO, 2010)

According to the Manual of Mortar Mechanized developed by COMUNIDADE DA CONSTRUÇÃO (2012), implementation steps are as follows: cleaning the base, roughcast, taliscamento, applying the mortar. in the first step have the coarse and fine cleaning steps identical to manual application method. In the second stage the roughcast will have particularities compared to the manual method of application; since this must be operated by means of continuous projection, in order to ensure homogeneity throughout the length of the wall. Since the end of each work shift during the first two days of execution should proceed to roughcast of healing through water spray across the newly implemented area (COMUNIDADE DA CONSTRUÇÃO, 2012). The third stage (taliscamento) should be performed in order to be fixed in accor-
dance with the quotas set in the project mapping (COMUNIDADE DA CONSTRUÇÃO, 2012).

For implementation of the fourth stage is necessary to wait three days from the placement of roughcast (deadline set by the NBR 7200). Then, the roughcast revisions are done, so that possible situations of low adhesion and / or brittle, indicating the need for removal or replacement, especially on concrete structure. The fifth stage is constituted by the launch of the mortar in which are defined the panels to be filled with projection horizontally, in a single mass. The concept of single mass is connected to the single layer of mortar applied on the roughcast, fulfilling the functions of plaster and mortar, as described above. The sarrafeamento is done next and performed with aluminum strip, being able to press the plaster on the base with ruler and trowel in places of difficult access. Reaching the straighten time, makes up the finishing trowel with straightener in through circular motions, under slight pressure, with straighten thick with regular and compact surface.

The periodic Construção Mercado (2010) states that: “Whether by container’ or pump, the advantages of the projection method of the manual are not few, beginning with the quality of the coating. When properly applied, the projection dramatically decreases the amount of air in the process and, as a mechanical procedure, the mass release of energy does not change, ensuring greater contact surface between the mortar and the base and less variation in the coefficient of grip”.

According to Comunidade da Construção (2012) the use of mechanized systems for the execution of mortar coatings, either in internal or external walls, gives the builder many gains, among which are: Deadlines, quality, rationality, productivity and cost. As for deadlines, It's possible to achieve significant gains in periods defined in the budget. As for quality, It's possible to see the lower dependence on labor ability at the end performance of the service, providing the lowest variability of processes. Furthermore, it is possible to have a more efficient control of the materials used compared with traditional systems mortars produced on site. As for rationality, the construction sites are cleaner because of the independence of the services, facilitating the execution of control operations. Regarding productivity, the same amount of services can be performed with a smaller contingent resulting in a reduction in the cost of labor due to mechanization of mixing, conveying and projection. As for costs, There is a reduction in execution time, with fewer professionals involved, which can be translated into a lower cost per unit of work performed.

2 COMPARATIVE ANALYSIS

This research article aims to make a comparative analysis between manual and mechanized application of the external coating with cement mortar, through the case study on a construction site located in the city of Feira de Santana.

In order to achieve the proposed objective, data were collected in construction site in analysis, so that once analyzed, could provide support for the conclusions that will being taken.

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6 It’s a process of fixing of taliscas, with the purpose to ensure the vertical alignment of the coating.
7 In Portuguese, also called Canequinha.
Table 1 below shows the basic information of the construction for unification of comparative parameters.

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Manual</th>
<th>Mechanized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area per constructive unit</td>
<td>m²</td>
<td>1030</td>
<td>1030</td>
</tr>
<tr>
<td>Coating thickness</td>
<td>m²</td>
<td>0,02</td>
<td>0,02</td>
</tr>
<tr>
<td>Coating volume</td>
<td>m³</td>
<td>20,60</td>
<td>20,60</td>
</tr>
<tr>
<td>Quantity of betonadas&lt;sup&gt;8&lt;/sup&gt;</td>
<td>m³</td>
<td>3,42</td>
<td>3,42</td>
</tr>
<tr>
<td>Execution period per constructive unit</td>
<td>working days</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>Business days in the month</td>
<td>working days</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Monthly Productivity In Index</td>
<td>Month/constructive unit</td>
<td>0,86</td>
<td>0,45</td>
</tr>
</tbody>
</table>

Table 2 and 3 are given the respective sizings of staff for each technique, their individual remuneration values and labor accessories cost, as incentives and benefits, both associated with compliance with pre-established goals; instrument commonly used in the region. In order that this cost is taken as the basis for composing the costs involved with staff.

Table 02 Labor costs (Manual Coating)

<table>
<thead>
<tr>
<th>Employee</th>
<th>Quantity</th>
<th>Salary (month)</th>
<th>Incentives</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mason</td>
<td>6</td>
<td>R$ 1.282,45</td>
<td>R$ 90,88</td>
<td>R$ 8.240,00</td>
</tr>
<tr>
<td>Attendant</td>
<td>3</td>
<td>R$ 751,54</td>
<td>R$ 0,00</td>
<td>R$ 2.254,62</td>
</tr>
<tr>
<td>Social Charges (Hourly)</td>
<td></td>
<td></td>
<td></td>
<td>137,00%</td>
</tr>
<tr>
<td>Labor cost (month)</td>
<td></td>
<td></td>
<td></td>
<td>R$ 24.872,25</td>
</tr>
<tr>
<td>Monthly Productivity In Index</td>
<td></td>
<td></td>
<td></td>
<td>0,86</td>
</tr>
<tr>
<td>Labor cost (constructive unit)</td>
<td></td>
<td></td>
<td></td>
<td>R$ 21.480,58</td>
</tr>
</tbody>
</table>

Table 03 Labor costs (Mechanized Coating)

<table>
<thead>
<tr>
<th>Employee</th>
<th>Quantity</th>
<th>Salary (month)</th>
<th>Incentives</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mason</td>
<td>4</td>
<td>R$ 1.282,45</td>
<td>R$ 777,55</td>
<td>R$ 8.240,00</td>
</tr>
<tr>
<td>Attendant</td>
<td>2</td>
<td>R$ 751,54</td>
<td>R$ 278,46</td>
<td>R$ 1.781,54</td>
</tr>
<tr>
<td>Social Charges (Hourly)</td>
<td></td>
<td></td>
<td></td>
<td>137,00%</td>
</tr>
<tr>
<td>Labor cost (month)</td>
<td></td>
<td></td>
<td></td>
<td>R$ 24.411,00</td>
</tr>
<tr>
<td>Monthly Productivity In Index</td>
<td></td>
<td></td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td>Labor cost (constructive unit)</td>
<td></td>
<td></td>
<td></td>
<td>R$ 11.095,91</td>
</tr>
</tbody>
</table>

In order to compare the results of labor costs with a recognized and external parameter to the study, it was added an analysis of the activity based on harvested productivity indices by TCPO (2013). The values are disclosed in table 4.

<sup>8</sup> It's quantity of mixture of relative proportions of ingredients of concrete that fit in the concrete mixer.
By identifying that the main factor in the comparison between systems is associated with the deadline in the execution of the task, it separated only the costs of labor, and both were compared with the values associated with indices by TCPO (2013).

<table>
<thead>
<tr>
<th>Employee</th>
<th>Index (TCPO)</th>
<th>Hour/month</th>
<th>Incentive (m2)</th>
<th>Area (m2)</th>
<th>Cost constructive unit for labor cost (constructive unit)</th>
<th>Social Charges (Hourly)</th>
<th>Total cost of labor (constructive unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mason</td>
<td>0.92</td>
<td>R$ 5.83</td>
<td>R$ 0.41</td>
<td>1030</td>
<td>R$ 5,915.32</td>
<td>137%</td>
<td>R$ 18,272.21</td>
</tr>
<tr>
<td>Attendat</td>
<td>0.51</td>
<td>R$ 3.42</td>
<td>R$ 0.00</td>
<td>1030</td>
<td>R$ 1,794.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor cost (constructive unit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>R$ 7,709.79</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Charges (Hourly)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>137%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 04 Labor Cost (PINI/TCPO)

It is observed according to Table 5 above that TCPO values (2013) are positioned between associated with manual application and mechanized application, that is, the manual application technique has a labor cost biggest than TCPO value comparative, while the mechanized application technique has a cost of labor value below than TCPO (2013) comparative.

In order to continue with the collection of data necessary for the execution of the outer coating on the table 6 and 7 are listed the various supplies involved in performing the activity, information which, together with labor, will compose the final cost of the analyzed activities.

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Price</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>sc</td>
<td>R$ 25,00</td>
<td>1.00</td>
<td>R$ 25,00</td>
</tr>
<tr>
<td>Sand</td>
<td>m³</td>
<td>R$ 18,00</td>
<td>0.30</td>
<td>R$ 5,40</td>
</tr>
<tr>
<td>Water</td>
<td>m³</td>
<td>R$ 15,66</td>
<td>0.08</td>
<td>R$ 1,25</td>
</tr>
<tr>
<td>Additive Plasticizer</td>
<td>kg</td>
<td>R$ 3.56</td>
<td>0</td>
<td>R$ 0.00</td>
</tr>
<tr>
<td>Equipments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Mixer</td>
<td>hr</td>
<td>R$ 3.82</td>
<td>0.12</td>
<td>R$ 0.45</td>
</tr>
<tr>
<td>Labor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operator</td>
<td>hr</td>
<td>R$ 5.63</td>
<td>0.12</td>
<td>R$ 0.68</td>
</tr>
<tr>
<td>Attendant (3)</td>
<td>hr</td>
<td>R$ 10.25</td>
<td>0.12</td>
<td>R$ 1.20</td>
</tr>
<tr>
<td>Social Charges (Hourly)</td>
<td>%</td>
<td>137%</td>
<td></td>
<td>R$ 4.45</td>
</tr>
<tr>
<td>Total/concreted</td>
<td></td>
<td></td>
<td></td>
<td>R$ 38.54</td>
</tr>
<tr>
<td>Concreted quantity for facade</td>
<td></td>
<td>88.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Supplies per constructive unit</td>
<td></td>
<td></td>
<td></td>
<td><strong>R$ 3,218.30</strong></td>
</tr>
</tbody>
</table>

Table 05 Comparative of Labor (PINI X OBRA)

Table 06 Supply Costs (Mortar without additive - Coating Manual)
Table 07 Supply Costs (Mortar with additive - Coating Mechanized)

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Price</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>Sc</td>
<td>R$ 25,00</td>
<td>1,00</td>
<td>R$ 25,00</td>
</tr>
<tr>
<td>Sand</td>
<td>m³</td>
<td>R$ 18,00</td>
<td>0,15</td>
<td>R$ 2,70</td>
</tr>
<tr>
<td>Water</td>
<td>m³</td>
<td>R$ 15,66</td>
<td>0,08</td>
<td>R$ 1,25</td>
</tr>
<tr>
<td>Additive</td>
<td>kg</td>
<td>R$ 3,56</td>
<td>0,80</td>
<td>R$ 2,85</td>
</tr>
<tr>
<td>Plasticizer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                     |      | Equipments |        |         |
| Concrete Mixer      | hr   | R$ 3,82    | 0,12   | R$ 0,45 |
| Operator            | hr   | R$ 5,83    | 0,12   | R$ 0,68 |
| Attendant (3)       | hr   | R$ 10,25   | 0,12   | R$ 1,20 |
| Social Charges      | %    | 137%       |        | R$ 4,45 |
| (Hourly)            |      |            |        |         |
| Total/concreted     |      | R$ 36,69   |        |         |
| Concreted quantity for facade | 88,07 |
| Cost of Supplies per structural unit | R$ 3,231,33 |

Table 8 are described equipment used in mechanized method of application, information necessary to make the comparative analysis.

Table 8 Mechanization Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rental of projector</td>
<td>Month</td>
<td>1</td>
<td>R$ 3,000,00</td>
<td>R$ 3,000,00</td>
</tr>
<tr>
<td>Rental Sieve</td>
<td>Month</td>
<td>1</td>
<td>R$ 480,00</td>
<td>R$ 480,00</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Month</td>
<td>1</td>
<td>R$ 1,000,00</td>
<td>R$ 1,000,00</td>
</tr>
<tr>
<td>Compressor Oil</td>
<td>lt</td>
<td>2</td>
<td>R$ 15,00</td>
<td>R$ 30,00</td>
</tr>
<tr>
<td>Grease (Gear)</td>
<td>kg</td>
<td>40</td>
<td>R$ 17,80</td>
<td>R$ 237,33</td>
</tr>
<tr>
<td>Total Cost (month)</td>
<td></td>
<td></td>
<td>R$ 4,747,33</td>
<td></td>
</tr>
<tr>
<td>Monthly Productivity In index</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment cost per constructive unit</td>
<td>R$ 2,157,88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on information collected by the previous tables were generated the numbers presented in table 9 below, which are disclosed the total cost per unit built, individualized for each of the techniques in question; wherein in item 6 of the same table, all of these fees are summed and then divided by the total area of the unit built to thereby have a representative number (per square meter), which facilitates comparative display systems.
Table 09 Comparison of typologies

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Manual</th>
<th>Mechanized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor costs</td>
<td>R$/unit const.</td>
<td>R$ 21,480.58</td>
<td>R$ 11,095.91</td>
</tr>
<tr>
<td>Supply costs</td>
<td>R$/unit const.</td>
<td>R$ 3,218.30</td>
<td>R$ 3,231.33</td>
</tr>
<tr>
<td>Auxiliary Equipment Cost – Including Maintenance</td>
<td>R$/unit const.</td>
<td>R$ 0.00</td>
<td>R$ 2,157.88</td>
</tr>
<tr>
<td>Total Cost</td>
<td>R$/unit const.</td>
<td>R$ 24,698.88</td>
<td>R$ 16,485.12</td>
</tr>
<tr>
<td>Area per constructive unit</td>
<td>m2</td>
<td>1030</td>
<td>1030</td>
</tr>
<tr>
<td>Unit Cost</td>
<td>m2</td>
<td>R$ 23.98</td>
<td>R$ 16.00</td>
</tr>
</tbody>
</table>

One can observe a cost of R$ 23.98 (twenty-three reais and ninety eight cents) for the system with manual application, which, compared to the mechanized application system to a value of R$ 16.00 (sixteen reais), it will give a total cost savings on the order of 33.26% this difference is mainly due to the greater agility in implementing the mechanized method, which can easily be seen in table 1 who it can be seen that the unit constructive is performed at 10 days, while the manual method, the same activity is carried out 19 days, that is, approximately 50% (fifty percent) reduction in time.

In table 10 shows the values of supplies are again associated, showing the total costs associated with the activity (labor and materials). It can be seen that the trend observed in table 5, where the costs associated with mechanized application remains below the value TCPO (2013) comparative, and the values associated with manual application remains above the value TCPO (2013) comparative.

It can be seen in table 10 that the activities execution deadlines follow the same trend of total costs, ie, the longer the execution time, the greater will be the associated direct costs, which demonstrates the importance the agility of services in the composition the final cost of the activity.

Table 10 Comparative (Budgeted / X Executed Planning)

<table>
<thead>
<tr>
<th></th>
<th>Budget/Planning</th>
<th>Manual</th>
<th>Mechanized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost (R$)</td>
<td>R$ 35,617.22</td>
<td>R$ 21,929.89</td>
<td>R$ 16,485.12</td>
</tr>
<tr>
<td>Time (days)</td>
<td>14</td>
<td>19</td>
<td>10</td>
</tr>
</tbody>
</table>

It can be concluded that the mechanized implementation is economically advantageous in comparison with the manual technique, mainly by agility in the execution of the coating and lower cost. While that, the manual application caused injury as far as the costs as the time and thus can delay the construction schedule, generating overhead and other costs not foreseen in the schedule.

Another important conclusion is that being TCPO indices (2013) used as a basis for development of most budgets of construction companies, to study in particular, the manual technique of applying plaster, led to an operating loss for the activity under analysis.

3 FINAL CONSIDERATIONS

Comparing the costs of two typology, total cost related to the coating mechanized was 33.26% cheaper than the manual was obtained. Compared with the cost of TCPO (2013) with both types, It was obtained a cost of higher 17.56% manual and 39.27% cheaper in mechanized jacket and comparing with the budget.
It’s possible to see that the manual cost equivalent to 69.35% and 46.28% of the mechanized of final budget of the project. Therefore, it can be concluded that the outer covering mechanized fits perfectly in the current context of industrialization and rationalization of Civil Construction Industry of Feira de Santana. However, it is important to note that prior to insertion of a construction technique must analyze its viability and adaptation already in the design phase to construction logistics adaptation and training of employees, since the mechanization of steps leads to application more meters square in less time, requiring faster in the finishing services.

4 APPENDIX

<table>
<thead>
<tr>
<th>CODE</th>
<th>Description</th>
<th>Employee</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hourly</td>
</tr>
<tr>
<td>A</td>
<td>Basic Social Charges</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>Social Security</td>
<td>20,00</td>
</tr>
<tr>
<td>A2</td>
<td>FGTS</td>
<td>8,00</td>
</tr>
<tr>
<td>A3</td>
<td>Education salary</td>
<td>2,50</td>
</tr>
<tr>
<td>A4</td>
<td>SESI</td>
<td>1,50</td>
</tr>
<tr>
<td>A5</td>
<td>SENAI</td>
<td>1,00</td>
</tr>
<tr>
<td>A6</td>
<td>SEBRAE</td>
<td>0,60</td>
</tr>
<tr>
<td>A7</td>
<td>INCRA</td>
<td>0,20</td>
</tr>
<tr>
<td>A8</td>
<td>INSS</td>
<td>3,00</td>
</tr>
<tr>
<td>A9</td>
<td>SEONCI</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>SUBTOTAL A</td>
<td>36,80</td>
</tr>
<tr>
<td>B</td>
<td>Social Charges receiving incidence in A</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>Weekly rest and holidays</td>
<td>22,9</td>
</tr>
<tr>
<td>B2</td>
<td>Illness Aid</td>
<td>0,79</td>
</tr>
<tr>
<td>B3</td>
<td>Paternity leave</td>
<td>0,34</td>
</tr>
<tr>
<td>B4</td>
<td>13 Salary</td>
<td>10,57</td>
</tr>
<tr>
<td>B5</td>
<td>Rainy days / absences justified/ other difficulties / accident at work / strike / failure or delay in delivery of the material</td>
<td>4,57</td>
</tr>
<tr>
<td></td>
<td>SUBTOTAL B</td>
<td>39,17</td>
</tr>
<tr>
<td>C</td>
<td>Social charges that do not receive incidence of A</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Deposit for wrongful dismissal 50% of (A2 + A2X B)</td>
<td>5,56</td>
</tr>
<tr>
<td>C2</td>
<td>Indemnified holiday</td>
<td>14,06</td>
</tr>
<tr>
<td>C3</td>
<td>Early warning</td>
<td>19,44</td>
</tr>
<tr>
<td></td>
<td>SUBTOTAL C</td>
<td>39,06</td>
</tr>
<tr>
<td>D</td>
<td>Recidivism</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>Recidivism A on B</td>
<td>14,81</td>
</tr>
<tr>
<td>D2</td>
<td>Recidivism A 2 on C3</td>
<td>7,18</td>
</tr>
<tr>
<td></td>
<td>SUBTOTAL D</td>
<td>21,97</td>
</tr>
<tr>
<td></td>
<td>Total Social Charges (%)</td>
<td>137</td>
</tr>
</tbody>
</table>
5 REFERENCES
_____.
_____.
_____.
_____.


Dissertação (Mestrado) - Curso de Engenharia, Departamento de Escola de Engenharia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2008.


The parallel management using concurrent engineering: the case of constructions at nuclear submarine development program.

Vania Menezes Pereira da Silva¹

¹The author holds degree in Civil Engineering and Law. Master degree in Urban and Environment Engineering. Lawyer and Civil Engineering at Brazilian Navy.

ABSTRACT

The concurrent engineering is an important and modern method of management that get better results when there are needs of simultaneous decisions and, in case, simultaneous actions. The constructions at nuclear submarine development program included its method to optimize and improve efficiency, since procurement to executions of the contracts.

Purpose of this paper (mandatory)

Study the methods, process analysis and organization of constructions at nuclear submarine development in a critical view in order to present the different decisions levels working together and build a framework that represent this parallel management.

Design/methodology/approach (mandatory)

The research will be based on empiric research, combining data experiences with data collected, interviews and analysing contracts. Also will use theoretical research.

Findings and value (mandatory)

The research will be based on analysing results of applications of principles of concurrent engineering, its implications and difficults. A framework showing the main critical paths will be presented in order to be a paper that will shall new researchs.

Research limitations/implications (if applicable)

If research is reported on in the paper this section must be completed and should include suggestions for future research and any identified limitations in the research process.
Originality/value of paper (mandatory)

The research is an important analysis of concurrent engineering application at construction, specially in an inedit management, using technology transfer at same time projects and constructions are made. Not only to Brasil navy but also to any company that need to deal with an unknown structure, the research is an important paper to be consulted.

Conclusions: ......................

Keywords: Concurrent Engineering. Construction Engineering. Brasilian Navy.

1 – INTRODUCTION

Brazilian Navy is the naval service branch of Brazilian Armed Forces which has multiple tasks. To be in order to conduct naval operations it has 280 constructions just as Naval Districts and Naval Bases1. It means that it is difficult to maintain all these constructions and it is not the focus in armed forces, especially when it has to be up to date with technologies in order to have power projection in defense of its sovereignty.

Power projection here is the capacity of a state to apply national military power to rapidly and effectively deploy and sustain forces in and from multiple dispersed locations to respond to crises, to contribute to deterrence, and to enhance regional stability. And its importance points to international relations. Brazilian Navy must maintain peace and take care of its oceans, rivers and lagoons, but to have a power projection needs to be able to direct its military forces outside the limited bounds of its territory. And it is so important that Alfred Thayer Mahan2 describes its influence in history, describing that a study of the military history of the past is enjoined not only by power sea but by great military leaders as essential to correct ideas and to the skilful conduct of war in the future, and also influence on developing new technologies.

So, this ability – power projection - needs new Technologies to sustain modern forces and that is too expensive. That is why it is a challenge Brazilian Navy keep constructions usable, managing a maintenance program and, at the same time, include in government resources these costs without impacting the entire budget feature.

Control all budget resources and distribute then needs a serious commitment and nowadays it is getting a big effort of all military because of the minimum money available for Government. Each one in its specialty on the air, sea, earth, or administrative competence. And to include new technology the Brazilian Government had to get a big part of its budget resources which is a real need meaning that power projection walks alongside economy just like said by Alfred Thayer Mahan.

To increase power projection Brazilian government signed an international agreement with France to get new technologies knowledge on constructing a nuclear submarine\(^3\). It is one of many tasks in national defense strategy\(^4\) - Law n. 6.703, December 18, 2008 - that includes nuclear sector. Then, an international agreement was signed in 2008 and then Brazilian government gave to Brazilian Navy a mission: to make real Brazilian nuclear submarines.

France new knowledge includes since a project of a hull nuclear submarine to constructions of an especial Naval Base and also Shipyards to build and maintain the nuclear submarines.

![Picture 1: Nuclear submarine development site. From: https://www1.mar.mil.br/prosub/](https://www1.mar.mil.br/prosub/)

The especial new Naval Base is at Baía de Sepetiba, Rio de Janeiro. The new Shipyards are also located at Baía de Sepetiba.

![Photo 1: Itaguaí. Nuclear submarine development site. Files belong to author.](https://www1.mar.mil.br/prosub/)

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With these new status Brazil will be the sixth country in the world with nuclear a nuclear submarine. In a military and strategic point of view with this new technology Brazilian government will increase power projection and will get bigger respect in terms of nation,

It is an important and a special moment and project management is a valuable instrument to discipline planning, executing, controlling and closing the work of a team to achieve specific goals and meet specific success criteria. And Brazilian Navy is using modern technics to make the best management not only to refund but also to nuclear submarine project.

The main challenge is to do all new steps without knowing them. This means that all steps are unknown because of the transfer of technology and its secrecy from France. So all steps are made with no idea of which one will be the next.

It generates many problems. At the same time have to be done the construction project, constructions, development of nuclear submarine and all this must be done in a harmonic way, but independent of each other.

A new way of plain, check, do and review steps had to be discovered looking for a minimum waste of a public budget and a maximum timeline. Plan, check and do at same time, in a parallel management influencing each other getting the best project performance.

Facing this challenge at nuclear submarine development program concurrent engineering presented the best solution to improve all management steps. Concurrent engineering is a work methodology based upon parallelization of tasks. It may be called simultaneous engineering or integrated product development (IPD).

And this type of management can be used in military projects specially on those which needs parallel tasks just like nuclear submarine development program when the next step is unknown dependent on technology transfer and technological innovation knowledge. So establishing a concurrent engineering plan means to get the better effort to do what have to do in a better way optimizing methods, improving cooperation performance, getting a result oriented management but at same time doing all stuffs in a parallel way in order to reduce the constructive errors and resource management.

There are many fundamentals in concurrent engineering and approach to development has two major themes. The first theme is establishing an integrated product and process organization (PPO). This is referred herein as process taxonomy. The second theme is applying this process taxonomy (or a set of methodologies) to design and develop a total product system. This is referred to as integrated product development (IPD). The IPD process is the one which is useful to nuclear submarine development program because of the parallel way of managing something unknown and unprecedented in almost all countries.

Its novelty has created many situations that depended on original decisions and original methods. This has been the greatest challenge of Brazilian Navy.

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2 – THE IMPORTANCE OF A PROJECT MANAGEMENT

There are many project management policies, which one using its special way to check, do, make and act in order to get the best situation not wasting time and achieving lower cost. Big corporations need special management just to be competitive in market. New products need special management to get your peak performance in obtaining results.

Project management is a method used in the development of a product or service⁶. It means that integrate all parts in one direction needs an effort of all team pointing the results to one goal: the best product in a minimum effort, cost and time.

![Team group working parallel. From: https://www.linkedin.com/pulse/equipe-de-projetos-gerenciamento-baseado-guia-pmbok-diego](image)

At first, a team may seem to be in a complex problem. Also may seem to be in a chaotic order. Or in a complicated problem. What you have to do if you are the team leader? How can you modify old methods? How you can manage people? What you have to do in order to stop disorder?

Management is a great solution to answer these questions. Apart from this, modern problems is beyond simple development products. Nowadays management is a big instrument to those projects which have many tasks to develop at same time.

In this way, Nuclear Submarine Development Program need a special management to do all tasks at same time but without knowing next step. This configuration depends at same time getting new technology and knowledge doing constructions without knowing exact what will be in that construction.

It can be seen that it is not only a construction project but also a product development project. That is why it needs an integrated management.

Therefore, Brazilian navy engineers just know some needs described by France engineers in order to make constructions come true. These instructions contain very low specifications and it is a challenge to make this instructions be a final project.

Another difficulty must be strictly observed in Nuclear Submarine Development Program: materials specifications. Sometimes materials specifications cannot be used just because they are not within the Brazilian standards.

Facing all these difficulties an important conclusion is that project management is useful to organize all this mass. Cinanfin model is a useful toy to introduce this discussion just like this chart:

*Picture 3: Chart of a cinanfin model.*

The main characteristics of project are:
- performed by people;
- constrained by limited resources;
- planned, executed and controlled;
- temporally and unique;
- definite beginning and end.

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Progressive elaboration is a characteristic of a project that integrates the concepts of temporary and unique. Because of this, the product must be developed in steps. It means that it continuing steadily by increments. The distinguishing characteristics of the product will be made more explicity and detailed as the team develops a better and more complete understanding of the project.

Project management includes a basic structure that rises as a framework (project management framework) and process depends on the areas (project management knowledge areas). Project management knowledge areas includes many process such as integration, scope, time, cost, quality, human resources, communications, risk and procurement.

Projects are composed of processes that are series of actions that brings about a result. The actions depends on a team, on persons and there are two things that have be considered in order to solve problems: Project management process and product-oriented process. Product-oriented process specify and create the project’s product.

Project management processes describe, organize and complete the work. It has five parts or five groups just as:

- Initiating processes – authorizing project or phase
- Planning processes – defining and redefining objectives and selecting the best alternative
- Executing processes – coordinating people and other resources
- Controlling processes – control objectives project by monitoring and measuring progress regular-ly
- Closing processes – formalizing acceptance

All processes needs know inputs and outs in order to decide the right tools and technics of project management. This design consist on studying all needs and steps including client, product and organization.

There is no doubt that study all steps with management technics and use its tools is as important as the product itself because program management will make it become real in a low cost, short time, better development with persons integrated and interested in the production system and organization objectives.

2.1 – Modular enterprises

A program is a group of relation projects managed in a coordinated and efficient way in order to get benefits and control that would not be available if it would be done in a single management.

In order to coordinate the nuclear submarine development program, that includes all constructions to build the submarine and its maintenance, Brazilian navy designed modular enterprise.

SGM-101⁸, third review, is a Brazilian Navy standard that rules Director planning management. This docu-
ment describes modular enterprises, in chapter 5, as:

The modular enterprise is a group of internal actions representing a module of a general goal which its creation needs a decision from a high level planning and where the size and complexity needs the achievement of independents partial goals, harmoniously part-timed, making real planned goal.

The same standard explains what kind of enterprise is included in SGM-101 describing that another standard, EMA-420\(^9\) - chapter four, provides submarine as a modular enterprise.

1.4 – Coverage
Process that are described in this chapter must be applied to obtain naval assets:

... 

b) submarines 

... 

h) obtaining and modernization system described in this edition is also used in modular enterprises that in despite of not having this kind of operation as a main purpose includes actions just like these as an integrated goal.

These two Brazilian Navy standards named Nuclear submarine development program as a modular enterprise. The modular enterprises needs a chief executive. The chief executive of nuclear submarine development program is Coordenadoria-Geral do Programa de Desenvolvimento do Submarino de Propulsão Nuclear (COGESN). It is a military headquarter that control and coordinate the others headquarters that has one mission in submarine development.

The others headquarters were joined to offer and support especial tasks such as it is described in their usual mission. This support makes these headquarters as a unique team in despite of having others functions that can be stopped. These headquarters were named shareholder-manager and use part of its power to achieve the main goal.

Construction is one task that Diretoria de Obras Civis da Marinha is responsible. Integrated in nuclear submarine development program provides engineering services such as review projects, costs and even fallow construction work in order to guarantee correct implementation of all proposed measures.

A modular enterprise include a type of management objecting results in a unique goal using all power that exist in organization. That is why Diretoria de Obras Civis da Marinha was elected to take place in...

---

nuclear submarine development program because it has experience and engineers for construction.

**Photo 2:** Barão de Ladário Building. Site of Diretoria de Obras Civis da Marinha. File from author.

This management include many headquarters, each one using its skills in order to obtain the best product.

The project is becoming a reality in Itaguaí, Rio de Janeiro. The Metallic Manufacture Unit is already in line and the first part of submarine comes true. And to get this part-goal construction was an important action including analyzing costs, materials specifications, plants, obtaining licenses and others participations.

**Photo 3:** Unit of Methalic Sstructure Construction (UFEM). From https://www1.mar.mil.br/prosub/ufem

Nuclear submarine development program is a big project and includes new technology and innovation. It
can be said that it is the most important project at Brazilian Navy nowadays. Because of this, the number of needs is so big and different that a shareholder-manager that is responsible for constructions (Diretoria de Obras Civis da Marinha) had to get external support in order to work with a partner that have more expertise in some special areas.

In order to improve its construction support Diretoria de Obras Civis da Marinha contracted Instituto Brasileiro de Engenharia de Custos (IBEC). This contract is important because the project is temporary. So it has a beginning and end in a matter of a fact to make a selection process will be a big cost for 30 (thirty) years. Nuclear submarine project is expected to end many years before this.

Absolutely the participation of IBEC observes confidentiality and includes some expertise that Diretoria de Obras Civis do not have. It is also important that an external organization provides a better knowledge just like in this contract.

Many plants and standards in plants that are made by France, a result from an international contract, are a challenge if the specification do not exist in Brazil. Another thing is to prepare all needs without knowing how construction will be used such as the submarine is not prompt yet.

Picture 4 Plant of Brazilian nuclear submarine. From http://democraciapolitica.blogspot.com.br/2012/03/camin-
ho-do-submarino-nuclear-brasileiro.html

IBEC supports Diretoria de Obras Civis da Marinha making not only analysis about costs but also supporting some specialties specifications that cannot be supported by Diretoria de Obras Civis da Marinha because of its new technologies and inovation.

Therefore environment have standards that Brazilian Navy must respect, the same for all different kind of specialty must be done.

To provide a better service in Nuclear submarine development program there is no doubt that modular
enterprises is a good way to administrate this program. Not only to administrate but execute itself.

**3 – THE PARALLELISM IN CONCURRENT ENGINEERING**

In order to improve corporation’s performance there is a good method of project management which name is concurrent engineering.

This method join all existing skills for execute all tasks that are objecting same goal. So concurrent engineering is a work methodology based on the parallelization of tasks. It is also called as simultaneous engineering or integrated product development.

It refers to an approach used in product development and its functions including design engineering, manufacturing engineering and other functions. One proposal of this integration is reducing the elapsed time required to bring a new product to the market.

There are many elements in concurrent engineering such as cross-functional teams, concurrent product realization, incremental information sharing and integrated project management. Several companies and organizations are using concurrent engineering. Some examples are European Space Agency, American Space Agency (NASA), French Space Agency (CNES), Italian Space Center (ASI).

Many of these organizations works with new technologies and unknowing results just as nuclear submarine development program. That is why concurrent engineering is so important because using this method everyone have a special expertise but also knows all objectives. So, in despite of unknowing all results all team works together in order to achieve the same goal of those who are just working in a part of the project. It is a useful integrated product development that was designed since old years.

Biren Prasad10, in Concurrent Engineering fundamentals (1997), describes that in concurrent management there is the first part that is establishing an integrated Product and Process Organization (PPO). And This is a process taxonomy. The second part is how to use this set of methodologies to design and development a total product system. Concurrent engineering system controls each modification of the product that represents a taxonomical relationship between specifications (inputs, requirements and constraints), outputs, and the concept it (the modifications) represents.

The author continuous explanation:

At the beginning of the design process, the specifications are generally in abstract forms. As more and more of the specifications are satisfied, the product begins to take shape – begins to envolve into a physical form. To illustrate how a full CE (concurrent engineering) system will work, and how to show the inner-working of its elements, author defines this CE system as a set of two synchronized wheels.

The synchronized wheels of a bicycle is analogous to this system.

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The first wheel includes integrated product and process organization. The innermost ring in this first wheel is a hub that represents the four elements of concurrent engineering models (information modelling), method (product realizations taxonomy), metric and measures.

The middle ring in the first wheel represent the groups of persons that drives the organization, just like that one who drives the bike. Divided in four groups there are personnel team, technology team, logical team and virtual team. The outer ring for each wheels has eight parts.

Product design, development and delivery differs as its complexity differs and it depends upon six dimensions. The first dimension is types of information and sources second one is complexity of tasks, third one degree of their incompleteness or ambiguity, fourth is timing of decision making, fifth is order of decision making and last one is communication mechanism.

An important thing is that elements of the first wheel can use these six dimensions together. It is made by a set of system and processes.

The second wheel of the bike defines the integrated product development (IPD) in order not to be a step-by-step process but an concurrent process with a different framework. Team groups are considered in all process and have opportunity to achieve overall progress towards a finished product. Team groups also can use many techniques. There are 9 important techniques.

- concurrent function deployment –
- metrics and measures –
- total value management –
- product development methodology –
- framework and architectures -
- capturing life-cycle intent –
- decision support system –
- intelligent information system –
- life-cycle mechanization (iqual CIM + automation + CE) –
- Concurrent engineering provides decision to support element and
- IPD deployment methodology.

All these nine techniques together can synchronize the two wheels and a conception of this bike is designed in picture 5.

Picture 5 The wheels in a bike and concurrent engineering, designed by BirenPrasad. From https://www.researchgate.net/publication/258840215_Concurrent_Engineering_Wheels
The main goal in concurrent engineering is to manage all parallel tasks in the best way it can be done, including all parts since designing up to development and giving it back with new nature.

3.1 – Concurrent engineering and nuclear submarine development program

Nuclear submarine development program has many different needs and therefore many different tasks at the same time. Everything has to be in order to happen suddenly but not so suddenly as it is not prepared to begin its development.

Brazilian Navy works ordinary with goals and results with CDMA method (check, do, make and action). Concurrent engineering is a real need in the special case of nuclear submarine development program and its constructions just because new technologies and innovation includes parallel tasks.

An example for this is constructing a ship repair ships. Meanwhile it does not exist a nuclear submarine with weight, high, dimensions a ship repair for it is a parallel construction. In order to be up to date with France specifications (country that have all needs and technology transfer).

Using many methods just like considered in this chapter Brazilian Navy made a division and created teams just like expertise partners such as Diretoria de Obras Civis da Marinha (constructions) or Diretoria de Engenharia Naval (naval constructions). These partners are oriented by Coordenadoria-Geral do Programa de Submarino Nuclear (COGESN), the chief manager in a integrated project management. It ensures that someone is responsible for the entire project (COGESN) and the responsibility is not abdicated once one aspect of the work is done.

Using modular enterprises, constructions is one of them. These modular management is using concurrent engineering because the elements of CU are observed in it.
As teams are partners, uses cross-functional teams. This includes members from various disciplines involved in the process.

As product depends upon external knowledge and doing several things at once it has to use concurrent product realization. To support it designing various subsystem simultaneously is a goal in concurrent engineering.

As training and analysis performance, incremental information sharing and integrated project management join all teams and also reduces mistakes because everyone knows each information as fast it can achieving effective sharing.

4 – CONCLUSION

Brazilian navy need to keep updated and current with defense technologies. For this, need to stay on the edge of world development. Nowadays this possibility becomes a true because of an international agreement with France and Brazil to transfer technology to construct a nuclear submarine and facilities for this that includes constructions.

Transfer technology includes submarines to be built, assembled and maintained on construction sites with the support of a naval base and a radiological complex. In order to achieve this goal the method of concurrent engineering can order the multiple parallel tasks and organize many team groups.

A useful action is to use modular management where there is a chief manager. In despite of existing a chief manager, everyone knows all steps every time it is revealed. Headquarters with its specialties were named shareholder-manager and use part of its power to achieve the main goal.

Diretoria de Obras Civis da Marinha is a headquarter that works to COGESN (chief manager) in order to be a shareholder-manager and keep the objectives in line.

It can be said that the Concurrent Engineering is an evolution of sequential engineering in order not to be a step-by-step work. Because of this can anticipate the detection of problems. So using concurrent engineering there is no more work in order to reconcile the steps already finished. The new way is work in an integrated multidisciplinary team requiring the prior effort in order to change organization and culture of the agent.

Nuclear submarine development program need to use concurrent engineering not only because it is an important tool to enhance the success of the design process but also because the unknowing next steps, absorption of new technologies and innovation construction that had never made in Brazil.

Concurrent engineering is the best way to eradicate the inefficiencies of sequential engineering model, maximize teams skills and may do parallel tasks at same time. It is perfect to technology transfer from France to Brazil. Concurrent engineering integrates knowledge with constructive experience during design, planning and execution of the work in order to simplify steps.
There are many benefits on using concurrent engineering in nuclear submarine development program such as reduces of time and product launch, reduces costs, improve quality and integrates design and production activities.

5 – REFERENCES
The Impact of the Cost of Absenteeism in a Printing Company

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ABSTRACT

Absenteeism is regarded as a problem in businesses because it adds costs and negatively impact on the performance of the organization. In this manner, the object of the present study is the representation of the cost generated by absenteeism in the finishing section of a printing company. In order to do so, it is necessary to research the concepts that involve accounting costs and absenteeism and understand costs with absenteeism. It was conducted literature exploratory research and field research, interviews with the managers of the Human Resources and the Controller’s office of the company. This study shows that absenteeism is a factor that impacts the company’s costs, and therefore should be monitored.

Keywords: Absenteeism, Cost Accounting, Personnel Cost, Absenteeism Cost.

1 Introduction

In the current new organizations included in a market of competitiveness and innovation, man, as a human being, is increasingly adapting to cultural, political and social transformations since ancient civilizations in order to understand the constant changes that occur in the scenario that involves work.
Managers face challenges about striving for competitiveness and for meeting the demands of a new market that require organizations to find procedures that add value to processes at lower cost. In order to ensure good performance, companies need to implement ongoing improvements by identifying factors that can influence the increase in costs, such as absenteeism.

The increasing rates of absenteeism have become a major problem in organizations, directly impacting on people management and, as a consequence, on the results of the company as a whole.

Absence from work affects productivity and thereby leads to an increase in costs. Some analysis indicate that absenteeism is inversely proportional to satisfaction at work, so it is necessary to observe elements related to working conditions because absenteeism can be treated as an indicator of quality in labor relations.

When observing the absence of employees from work and understanding how it can negatively impact on the cost of the sector, the researcher decided it was necessary to study the representativeness of absenteeism costs in a particular business sector.

In this context, the objective of the present study is to assess the representativeness of the absenteeism cost in the finishing sector of a printing industry, and in order to do so, it is necessary to research the concepts that involve accounting costs and absenteeism and understand how processes the calculating the cost of absenteeism.

To fulfill the purpose, the methodology adopted was a literature review including the study of some authors such as Chiavenato (2008), Marras (2000), Milkovich and Boudreau (2000), and Pomi (2005) among others, as well as reviews of articles and dissertations available on electronic media, and a qualitative research on a case study about a printing company in the state of Minas Gerais, where it was conducted direct interview with the managers of the Human Resources and the Controller’s office of the company in study.

2 Origin and importance of Accounting

According to Leite (1997), accounting is an ancient activity, dated around 2000 years b. C. - although all information available is not highly accurate. It is known that the Chinese used accounting records and auditing budgets to manage government activities. Thus, “In the civilizations that flourished in ancient times in Egypt and Greece, accounting and auditing systems in public administration were also used” (LEITE, 1997, p. 16).

Accounting is a tool and a social science that provides necessary information for decision-making within and outside the corporate environment. As economic transactions were increasingly more complex, man started requiring more detailed records of these operations, positively forcing the evolution and improvement of accounting over the history of mankind.

In this manner, in the early days of accounting, managers developed bookkeeping strategies that could meet the needs of users to meet their demands in a time before accounting developments and technol-
In this context, every organization and dwelling uses accounting, regardless of their size, purpose or legal constitution. Users make their decisions by analyzing information that is extracted from the accounting, where the resources obtained are allocated. This makes it possible to determine economic performance and what position users take up today. The importance of accounting, in addition to providing all the steps described, is to provide its users with further financial statements from entities, companies and personal finances, but it also make predictions and take more assertive decisions with respect to future situations.

3 Cost Accounting

Cost accounting is the accounting part of science whose focus is the coherent study of expenses in order to obtain goods for sale or consumption; and goods, here, can be a product, a commodity or a service. It also consists in financial activities that collect, provide, verify and interpret the cost of goods, inventories, services and organization components in order to facilitate the management in the decision-making process. According to Ribeiro (2009), “Cost Accounting or Industrial Accounting is a branch of accounting applied to industrial companies.”

As defined by Leone (2000, p.19-20) Cost Accounting is:

[...] the branch of accounting intended to produce information for different management levels of an institution, such as support to the functions of performance establishment, planning and control of operations, and decision making.

Cost Accounting is continually related to industrial activities, and there is now a significant number of services providers that use the cost concept in the costing of their services.

4 Cost Accounting Terminology

The terms expenses, disbursement, investment, cost, expenditure, and loss are terms largely used on a daily base in organizations, and their meanings are easily mistaken. So, to be familiar with these terms is essential to understanding the management information resulted from the use of Cost Accounting.

4.1 Expense

Martins (2010) classifies “expense” as the purchase of a product or service of any nature that requires financial cost for the institution. This cost is represented by the delivery or by the promise to deliver a good that most often is characterized by money. The author says:

Expense is defined as a very broad concept that applies to all goods and services purchased; and there is expense on the purchase of raw materials and labor, both in production and in distribution; expenses on management fees, buying a property, etc. There is only expense in the act of transferring to the ownership of the good or service's company, that is, when there is the accounting recognition of the debt
Thus, “depending on the destination of the expense, it can be converted into cost or expenditure” (Megliorini, 2001, p. 7). In this context, other sacrifices are not included, that is, expenses do not include all obligations that the company has to bear, such as opportunity cost and interests on equity, since the nature of these bonds does not have application regarding the delivery of the assets.

4.2 Disbursement

Concerning the concept of disbursement, Martins (2010, p. 25) points out that “disbursement is the payment made in the purchase of a good or service, and may occur before, during or after the purchase order is issued, therefore outdated or not at the time of the expenditure.” Thus, it can be said that disbursement is the effective outflow of money for payment of an obligation, and can be seen then that all disbursements is the result of an expense, and may be classified as cost, expense or investment.

Silva and Lins add that disbursement is:

[...] payment in cash resulting from the acquisition of the good or service. Disbursement can occur before, during or after the purchase order of the goods or services purchased. It is appropriate to recall that disbursement or payment is not taxable events of the recognition of the cost, but its use [...] (Silva; Lins, 2010, p. 9).

So to speak, disbursement is characterized as a financial event that corresponds to the payment for a good or service, regardless of the time of consumption. It is important to note that, because the events are recorded on an accrual basis, expenses are recorded regardless of whether the payment is made or not.

4.3 Investment

According to Martins (2010), the concept of investment is characterized by expenditure made in the purchase of a good or service, whether activated or not depending on its life span or due to the purpose intended. The same states that:

“Investment is responsible for all financial sacrifices due to the purchase of goods or services (expenses) stored in the company’s assets to reduction or amortization whenever it intends to spend, when it closes down or it devaluate, In these cases, it is specifically called investments (Martins, 2010, p. 25).

Martins (2010) believes that its natures can be diverse and present different periods of activation, which can be classified in different ways, respecting the purpose of its use and life span.

4.4 Cost

According to Dutra (1995), cost is somehow inserted into the life of any individual, from the mother’s womb to the end of their life, considering that all goods and services necessary for their livelihoods have an added cost: “Costs receive a classification and are grouped at the time of the accounting records in
order to limit the number of accounts in a list that is predetermined in the list of accounts of each company” (Dutra, 1995 p.29).

Martins (2010) says that cost is the expense aimed at goods and services employed is in the creation of new goods and services. According to the author (2003, p.25), “cost is also an expense, only recognized as such, that is, as a cost in the moment when using production factors (goods or services) to manufacture a product or running a service.”

4.5 Expenditure

According to Iudicibus et al (2003), the concept of expenditure lies in the use and consume of goods and services in favor of raising revenue. The author also states that:

In a strict sense, expenditure is the use or consumption of goods and services in the process of producing revenue. It is noteworthy that the expenditure can refer to expenses incurred in the past, present or to be carried out in the future. In general, we can say that the major factor that generates expenditure is the continued effort to produce revenue, since expense is a result of revenue, and revenue can derive from expense, that is, future revenue may be facilitated by past or current (or future) expenses. However, whenever goods or services are used in the production of goods that are still in the company, they are incorporated into the cost of the product and do not represent the expenditure or the cost of the period. (IUDICIBUS et al, 2003, p. 155).

HENDRIKSEN (1999 apud MOMOSE et al, 2005) defines expenditure as the use or consumption of goods and services in the process of obtaining revenue. Megliorini (2001) adds up that expenditure consists of goods or services that are consumed directly or indirectly in favor of raising revenue.

4.6 Losses

Losses are defined by the unconscious use of goods or services: fire, stock deterioration, leftovers, and burrs are some of the types of losses. Losses are also: events of exceptional circumstances, which are beyond the normal operations of the company. They are considered non-operational, and should not be part of the production costs. They are economic events negative to business assets, not usual, such as abnormal impairment of assets, exceptional loss of credits, abnormal idle capacity, etc. (PADOVEZE, 2006, p. 18).

4.7 Personnel costs

According to Dutra (2005), personnel costs represent all capital used with the staff, and which can be associated with the production, directly or indirectly in a given period. Thus, the cost in question was subdivided into two large groups: direct labor and indirect labor. Then, it is concluded that:

There are other classifiable costs such as personnel costs, but they can be seamlessly classified as direct and indirect cost of labor, because they usually occur due to direct or indirect labor (Dutra, 1995 p. 77).
Dutra (2005) concludes that personnel costs directly linked to core activity of the organization mean direct labor, while indirect labor is when collaborators do not operate in activities directly involved in the preparation of goods and services produced by the company.

5 ABSENTEEISM

According to Quick; Laplora (1982 apud ARAÚJO, 2012), the term absenteeism originates from landowners who left the countryside to settle in the city, and in the industrial era, it was applied to workers who lacked service.

In literature there is variations such as “leaveism” and “absence”, also used to denote the absence of the employee to work, which means the sum of the periods when the employees of a company or organization are absent from work. However, there is an absence motivated by unemployment, chronic diseases or legal license (CHIAVENATO, 1999)

In the words of Marras (2000), it deals with the absences in the workplace, as well as delays and early exits that occur during a given period. Absenteeism is indicated by a rate named after this very concept: rate of Absenteeism, whose function is to assist in the analysis of variations and trends of lost hours of work.

In this manner, for the National Labor Organization (1989 apud ARAÚJO, 2012),

Absenteeism is the absence of work by the employee, and absenteeism due to sick leave which consists of the labor downturn, considered the continuous period of absence from work due to a temporary disability of an individual for the task he was assigned to.

Benavides et al. (2001 apud YANO, SEO, 2006) make an addition explaining that the absence from work for some reason, which is better known as absenteeism, can be assessed by applying a quality index in labor relations (organization/employee) and the conditions of the working environment and quality of life factor at work. However, Chiavenato (2004, p. 86) states that

Absenteeism or absence is the frequency and/or duration of labor time which is lost when employees do not come to work. It is the sum of the periods when employees are absent from the workplace, either for leave, delay or any intervening cause.

Thus, absenteeism present a double effect, since in the employee’s point of view there is a possibility of suspension (in the case of non-justified leave), payroll deductions (when there is no sick note or any statement to justify the absence), possibility of dismissal (depending on the extent of the absence) and other related problems. In the employer’s point of view, the aggravating fact would be the difficulty in carrying out the activities planned for the employee and the problems that may arise due to their absence.
5.1 Absenteeism costs

Absenteeism causes a lot of uncertainty and unexpected situations in organizations, which leads to changes in the cost of goods and / or services. To Pomi (2005), absenteeism affects productivity negatively and generates higher costs, some of which can be easily identified while others depend on a more detailed analysis. Souto (1980 apud MARQUES; NETO, 2006), adds that in terms of cost, a constant rate of absenteeism of 5%, for instance, in reality means that the company needs 5% more staff than what is really necessary to the function because 5% of the staff is constantly away. Effectively, this is the immediate cost of absenteeism.

Therefore, since the usual production process is interrupted and then it is necessary to replace the absent professional, a probable reduction in production and quality is inevitable and starts to generate high costs, which is consequently added to the products or services, jeopardizing the economic return of the organization.

5.2 How to calculate the Rate of Absenteeism

According to Chiavenato (1999), the rate of absenteeism expresses the percentage of time not employed to work due to absences in the workplace in relation to the volume of activity expected or planned by the company.

Similarly, Marras (2000) says that it intended to assist in the analysis of inconstancy and predispositions to lost labor hours. Thus, the rate of absenteeism is calculated by the following formula:

\[
\text{rate of absenteeism} = \frac{\text{days of absence}}{\text{average staff} \times \text{number of days}} \times 100
\]

or

\[
\frac{\text{lost hour}}{\text{hours of labor}} \times 100
\]

Suppose that in a month with 27 days of work, for example, employee A is absent for 18 days, employee B is absent for eight days, C for 10 days, D for 10 days, E 2, F 8, employee G is absent 0 day and employee H is absent for 4 days.
Out of 8 employees, 7 were absent in some period. These 7 employees accounted for 60 days of absence during the month, which indicates that in this period the absenteeism in the company was 27.77%. This number shows that 60 total days of absence is the same as saying that the company worked with 2 employees this month, distributing the absence between them, and each of them did not work 30 days, or a month. Due to this impact on the productive force, companies attempt to find solutions to correct their rates.

### 6 Methodology

#### 6.1 Research Methodology

According to Prodanov; Freitas (2013) methodology is understood as a discipline based on exploring, understanding and evaluating the several methods available to develop academic research. Methodology analyzes, describes and evaluates research means and techniques that provide the collection and processing of information, aimed at guiding and solving problems and / or research questions.

Vergara (1998) classifies the research in two respects: as for the purposes and as for the means.

As for the means, the methodology adopted in the present study was a literature review which included the study of some authors such as Chiavenato (2008), Marras (2000), Milkovich; Boudreau (2000) and Pomi (2005), among others, as well as reviews of articles and dissertations available on electronic media.

According to Gil (1991), bibliographical research is developed from reviews of materials already developed; mostly books and scientific papers. Although in most studies is required some work of this nature, there are research developed exclusively from literature sources, and much of the exploratory studies is defined from literature searches.

As for the objectives, it was carried out a qualitative research, and no statistical tools were used in the process of analyzing the issue. Thus, we used a case study in a printing industry in the state of Minas Gerais, where it was conducted direct interview with the managers of the Human Resources and the Controller’s office of the company in study.

<table>
<thead>
<tr>
<th>Employee</th>
<th>Days</th>
<th>Days of Absence</th>
<th>Average Staff</th>
<th>Number of Days</th>
<th>Rate of Absenteeism</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>18</td>
<td>60</td>
<td>8</td>
<td>27</td>
<td>27.77%</td>
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<tr>
<td>B</td>
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<td>C</td>
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<td><strong>60</strong></td>
<td><strong>8</strong></td>
<td><strong>27</strong></td>
<td><strong>27,77%</strong></td>
</tr>
</tbody>
</table>
The present case study, according to Vergara (1998), is limited to one or a few units, understood as a person, a family, a product, a company, a government agency, a community or even a country. It is a deep and detailed research that may or may not be conducted on the field. This case study included the study of data related to rate and cost of absenteeism, which will be provided by the managers of human resources and the controller’s office of the printing industry in study.

6.2 Research tool

In order to achieve the objectives, it was used an exploratory-nature, field research aimed at providing full familiarity with the problem in order to make it clear and build hypotheses. Thus, the present paper was based on the use of primary and secondary data. As secondary data, it was used literature review by using materials already published such as papers, books, dissertations, digital media, etc. Thus, the work was complemented with the primary data, demonstrated through a case study carried out in a printing industry of Minas Gerais, used for knowledge detailing.

6.3 Procedure for data collection and analysis

According to Prodanov; Freitas (2013), data collection is the research phase aimed to extract information from reality. At this stage, we delimited where and how the search is conducted. It will determine the type of research, the population (research universe), sampling, data collection tools and how we intend to tabulate and analyze the data. It is the phase when data is grouped through specific techniques.

In this manner, the means used for data analysis were literature review and case study.

Literature review, according Marconi; Lakatos (2001), is the survey of all the literature published in books, magazines, press and random publications aimed at getting the researcher in direct contact with all that has been written about a subject [...].

According to Yin (2005 apud GIL, 2008), case study consists of an empirical study that scrutinizes a contemporary phenomenon within its real scope when the boundaries between phenomenon and context are not clearly defined, and in which several sources of evidence are used.

7 Case study

7.1 Characterizing the Institution

The company studied is a printing company, originally from Minas Gerais state, and one of the three largest in Brazil. It operates in the market since 1981, but it was in 1996 when it changed its focus to the production of business printing with large distribution combining price, efficiency and quality to serve the major brands in the country with international standard of printing quality.

The printing plant covers a building area of 258,000 sq ft, and a stock are of 130,000 sq ft to store paper and to print a very well known newspaper in the region of Minas Gerais.
The company in study has the average printing capacity of six million pages per hour, in an operation that takes six thousand tons of paper and 90 tons of paint per month and involves about 1100 employees, out of which 800 are direct employed and 300 are outsourced, trained in Brazil and abroad. Their client base includes retailers, wholesalers, advertising and promotion agencies, publishers, government agencies and religious bodies.

### 7.2 Research analysis

#### 7.2.1 Calculating the Rate of absenteeism

The calculation of the absenteeism rate constitutes an excellent indicator to support managerial decision-investment to prevention programs. Thus, rates of absenteeism presented from January 14th to December 14th, shown in Chart one, were calculated by measuring how many working hours were planned for all 430 employees of the company, not taking into account total hours of delay or total hours of absence. Then it was added the total hours of delay, hours of absence and early clock-out of all labor staff of the sector.

Then, the total number of lost hours was divided by the number of worked hours and, the result was multiplied by one hundred. This equation enables to find the absenteeism rate every month, as shown in the graph below.

Graph 01 - Rates of absenteeism in the sector in study from January 14th to December 14th

Graph 01 shows the 2014 record of the absenteeism rates of the printing company in study. It is noticed that in that year the absenteeism rates oscillated and was six months below the target and another six months above the expected target for the year surveyed. Thus, it is observed that the months of January, February, March, May, August and December were those who exceeded the expected goal. In other months, it was possible to achieve a positive result and keep below the target.
However, as shown in Graphic one, the absenteeism rate achieved an average of 2.10% during the period. According to Laselva (2012 apud Carneiro, 2012), the acceptable rate of absenteeism is around 1%. But in the sector we researched, rates ranged from 1.59% to 2.50%, which evidences that the rates found in the sector analyzed are high. They are, however, within a number expected for the sector in study, which is made evident by the goal set by the company’s managers.

7.2.2 Calculating the cost of absenteeism.

To calculate the financial cost of absenteeism in the printing company's sector in study, we used the average cost of each employee per month and divided by the number of days worked; the total found was the average cost of the employee per day. This average cost was multiplied by the amount of whole absences and hours of delays, which resulted in an average cash cost of absenteeism per month in 2014, which was the year used as study basis for this paper. The values per month are shown in the graph below.

![Graph 02- Financial representation of absenteeism in the sector in study from January 14th to December 14th](image)

By analyzing the values involving absenteeism, it was possible to see that they are values that draw attention and need to be worked in order to be minimized. In the year 2014, R$ 370,171.00 were spent in the absenteeism of employees of the finishing sector of the printing company in study. The economic impact demonstrated in Graph 02 is made worse by the demand for a downsizing of staff, the need to supply the absences, delays and early clock-out. Another aggravating factor is the expansion of the production costs and / or services, which also leads to an increase in the final cost of the product.

8 CONSIDERATIONS

The present study showed that the calculation of the rate of absenteeism constitutes an excellent indicator to support managerial decision-investment to prevention programs. Absenteeism negatively affects productivity and therefore stimulates an increase in costs. Motivated by this premise, this study approached the representation of the absenteeism cost in the finishing sector of a printing company,
and in order to do so, it is necessary to research the concepts that involve absenteeism and accounting costs, and also to understand how to calculate the cost of absenteeism.

By means of literature review and field research in the printing industry in the state of Minas Gerais, where it was conducted direct interviews with the managers of the Human Resources and the Controller's office of the company. It can be noticed that absenteeism is a factor of inflation and therefore must always be controlled.

By conducting interviews, it was possible to better understand the overall of costs related to absenteeism, and it was found that the company has the capacity, especially through organizational decisions, to reduce absenteeism levels and consequently reduce the costs generated by this absenteeism. Data analysis highlighted that the level of absenteeism in the sector is within the levels planned by the company in study although the literature points out that the acceptable absenteeism level is 1%, therefore, the sector must be monitored so measures are taken to maintain or even improve the presented rates.

It is important to note that when analyzing the cost of absenteeism in Reais, it was possible to see that those are worrisome values that need to be assessed in order to be minimized. It is worth remembering what it was pointed out in the literature study that the absence in the workplace, for any reason, can be understood as an indicator of quality in labor relations (organization / employee), of working environment conditions and quality of life in the workplace. It is suggested that, by means of the information generated, the industry focused on this study may evaluate management policies to be implemented in order to improve the performance of rates and values related to absenteeism. It is evident the need for monitoring absenteeism indicators because when controlled, they reduce the cost and improve the company's profitability.

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The characteristics of infrastructure construction cost estimating in Brazil

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1Contécnica Consultoria Técnica/CSL/STE

ABSTRACT

This paper aims to presents the procedures and regulations in relation to infrastructure construction costs estimating in Brazil. An overview including laws, decrees and decisions of the Brazilian auditing and accountability offices will be approached.

Infrastructure construction cost estimating in Brazil’s main regulation is the Law 8666/1993 that states, “Works and services may only be tendered when there is a detailed budget and the composition of all its unit costs.”

Nevertheless, cost estimating for projects financed by the Federal Government must follow Decree 7983/2013, which declares, in case of infrastructure works, the mandatory use of Sistema de Custos Referenciais de Obras (construction reference cost system) - SICRO, administered by the Departamento Nacional de Infraestrutura de Transportes (National Department of Transportation Infrastructure) - DNIT.

The SICRO, however, presents some chronic problems to be presented and in addition to these regulatory aspects and restrictions, one major problem is the interpretation of SICRO methodology by auditing and accountability offices, whose determinations have standard power to public agencies and often results in unilateral change of prices and quantities of contracts.

In some way, this excessive regulation of government construction cost estimating, limits the free practice of Cost Engineering in Brazil.

The regulation of the Federal Government results in hiring for low and sometimes distorted prices, based on minimum market values and not planned contract changes, sometimes forcing companies to reduce the contract price or even give back money already paid.

This paper promotes a basic overview of procedures and aspects faced for infrastructure cost estimating in Brazil.

Keywords: Brazil, cost estimating, construction, public administration, government, regulation, bid, auditing.
**APPROACH**

The cost estimation of infrastructure projects in Brazil has as main regulator the Law 8.666/1993 that states, “The works and services may only be tendered when there is detailed budget and the composition of all its unit costs”.

The cost estimation for infrastructure projects, including government grants, that use federal funds must follow the Decree No. 7.983/2013 that states the use of the National System of Costs Survey and Indexes of Construction (Sistema Nacional de Pesquisa de Custos e Índices da Construção Civil – SINAPI) for general construction projects and in the case of transportation infrastructure projects the use of the Construction Reference Cost System (Sistema de Custos Referenciais de Obras – SICRO), administered by the National Department of Transport Infrastructure (Departamento Nacional de Infraestrutura de Transportes – DNIT), object of the present case.

For compliance with such legislation, budgets should be prepared by the technique bottom-up and regardless of the type of project, must meet the class 1 of the AACE International Recommended Practice No. 18R-97

<table>
<thead>
<tr>
<th>DOCUMENT</th>
<th>REGULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Federal Constitution</td>
<td>Article 37, Section XXI - except for the cases specified in legislation, the works, services, shopping and disposals (public administration) will be hired through process of public bidding…</td>
</tr>
<tr>
<td>Law 8.666/2003 (bids and contracts)</td>
<td>Article 7, paragraph 2 The works and services (public administration) may only be tendered when: II - exist detailed budget in spreadsheets that express the composition of all its unit costs;</td>
</tr>
<tr>
<td>Decree 7.983/2013 (budgets)</td>
<td>Article 4 - The total reference cost of transportation infrastructure services and projects of will be obtained from unit cost compositions provided in the project that integrates the notice of bids, less than or equal to their corresponding unit costs in the Sistema de Custos Referenciais de Obras - SICRO…</td>
</tr>
</tbody>
</table>

**The Construction Reference Cost System - SICRO**

The SICRO defines the reference cost for the infrastructure works and services through a process of gradual composition of values (bottom-up technique), developed and administered by the Departamento Nacional de Infraestrutura de Transportes (National Department of Transportation Infrastructure) - DNIT. Its 2nd version, launched in 2000, was adopted by Federal Government as an official reference for infrastructure works due its consistent methodology and periodicity of price updates, done by the DNER staff up to 2012 and after 2013 by the Fundação Getulio Vargas – FGV a well-known private institution for economic education and studies, in cooperation with the DNIT.

The survey of equipment, materials and labour market prices is made every two months in almost all capitals of the Federation States.

The cost reports, as well as the manuals of SICRO original methodology, can be downloaded from the
The SICRO system calculates service costs, in the following steps:

I. Equipment cost in hourly basis;
II. Labour cost in hourly basis;
III. Conversion of hourly cost in unit cost by production rate;
IV. Material cost in unit basis;
V. Material transportation cost in unit basis;
VI. Auxiliary services (when necessary) in unit basis;
VII. Addition of BDI (overhead) for cost to price basis transformation.

**Equipment cost**

The equipment hourly cost calculated for the operating state (productive), and for the idle state. For the operating state the hourly cost is considered ownership costs, maintenance costs and operation costs, composed of:

- Ownership costs
  - Depreciation
  - Taxes and insurance
- Maintenance costs
  - Repairs
  - Undercarriage parts, tyres, brakes
  - Wearing parts
- Operation costs
  - Fuel
  - Oil, grease and filters
  - Operator labor

The equipment cost in the idle state considers only the operator labor, disregarding the other costs (depreciation, opportunity, fuel, taxes, wearing parts, etc.) The opportunity cost of capital is not considered in equipment costs under any circumstances.

**Labour cost**

The labour cost is the gross direct wages paid to the worker, plus labor burden that is composed of various taxes, social contributions and provisions that currently range from 90.64% to 120.37% over the wages, depending on the form of taxation adopted in contract and considers:

- Gross salary, plus;
- Contribution to the National Social Security Institute (INSS);
- Contribution to the Guarantee Fund for Employees (FGTS);
- Contribution to the Industry Social Service (SESI);
• Contribution to the National Industrial Apprenticeship Service (SENAI);
• Contribution to the National Institute of Colonization and Agrarian Reform (INCRA);
• Contribution to the Brazilian Service of Support to Micro and Small Enterprises (SEBRAE);
• Contribution to the Construction Industry Social Service (SECONCI);
• Educational salary;
• Work accident insurance;
• Weekend remuneration
• Provision for holidays;
• Provision for sickness aid;
• Provision for 13th salary;
• Provision for maternity leave;
• Provision for paternity leave;
• Provision for justified absences;
• Provision for adverse weather days;
• Provision for work accident aid;
• Provision for vacation;
• Provision for compensated layoff notice;
• Provision for worked layoff notice;
• Provision for compensated vacation;
• Provision for deposit for dismissal without just cause;
• Provision for additional compensation.

There are also additional expenses with transport, food and personal protective equipment for workers, which are considered in the unit cost compositions, as “labour additional” as 15.51% over labour cost.

Material cost

Unlike the inputs of labour and equipment, that require a series of preliminary calculations, so that their market values can be used in the computation of the unit cost of work and services, the purchase prices of materials are employed directly in the compositions, based on the lowest value reported.

Material transportation cost

The material transportation cost is considered as part of the total cost of the completed work, calculated by the unit cost compositions (CPUs), and considers:

• Time to load;
• Haul, loaded;
• Time to unload;
• Return, empty;
• Time dispended in manoeuvres to load and unload.
The reference price of a service is obtained by adding a quota called “Bonificação e despesas indiretas” – BDI (similar to overhead), that actually assumes values of 26.70% or 34.32% over the direct cost, depending on taxation option. The items BDI is composed and their values are presented in Table 2.

**Table 2 – BDI composition in 2016**

<table>
<thead>
<tr>
<th>Items</th>
<th>BDI (traditional)</th>
<th>BDI (relieved burden)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General &amp; administrative costs</td>
<td>3.76 %</td>
<td>3.99 %</td>
</tr>
<tr>
<td>Plant overhead</td>
<td>3.59 %</td>
<td>3.80 %</td>
</tr>
<tr>
<td>Financial costs</td>
<td>1.62 %</td>
<td>1.72 %</td>
</tr>
<tr>
<td>Risk</td>
<td>0.50 %</td>
<td>0.50 %</td>
</tr>
<tr>
<td>Insurance and contractual guarantees</td>
<td>0.32 %</td>
<td>0.34 %</td>
</tr>
<tr>
<td>Profit</td>
<td>9.12 %</td>
<td>9.67 %</td>
</tr>
<tr>
<td>Contribution for the social integration program - PIS</td>
<td>0.82 %</td>
<td>0.87 %</td>
</tr>
<tr>
<td>Contribution for the social security financing – COFINS</td>
<td>3.80 %</td>
<td>4.03 %</td>
</tr>
<tr>
<td>Services tax – ISSQN</td>
<td>3.17 %</td>
<td>3.36 %</td>
</tr>
<tr>
<td>Social security contribution on gross revenue</td>
<td>---</td>
<td>6.04 %</td>
</tr>
<tr>
<td>Total BDI</td>
<td>26.70 %</td>
<td>34.32 %</td>
</tr>
</tbody>
</table>

**Unit price composition - CPU**

The total unit reference cost of services is calculated using compositions forms, in which are considered the types and consumption of production factors for execution of a unit of service, such as, for example, 1 m³ of concrete, 1 kg of steel armour, 1 m of gutter, etc. An example of CPU is shown on Figure 1. There are distinct unit price compositions for construction, rehabilitation and maintenance services, differentiated by an efficiency factor applied in equipment cost.
**Production rate of services**

The production rate and operative and idle usage used in the CPUs are based on the equipment production for the service and calculated on the service technical features and equipment capacities and performance, by using a standardized form named Equipment Production (Produção da Equipe Mecânica) - PEM.

An example of PEM is shown on Figure 2
### Figure 2 - SICRO Equipment production

<table>
<thead>
<tr>
<th>SICRO CODE: 2 S 01 511 00</th>
<th>SERVICE: Soil compaction - Standard Proctor Effort</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>m³</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OCCURRING VARIABLES</th>
<th>UNIT</th>
<th>EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sheepsfoot vibratory roller 11.25t (82kW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor grader (103 kW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Harrow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility tractor (74 kW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tank truck (w/aater) 10.000 (210 kW)</td>
</tr>
</tbody>
</table>

| A - CLEARANCE            | m      | 10000                                                                      |
| B - CAPACITY             | m³     | 5000                                                                       |
| C - USAGE (QUANTITY)     | l      | 53                                                                         |
| D - DISTANCE             | m      | 150                                                                        |
| E - SPACING              | m      | 0.20                                                                       |
| F - THICKNESS            | m      | 0.20                                                                       |
| G - LOADING FACTOR       |        |                                                                            |
| H - CONVERSION FACTOR    |        |                                                                            |
| I - EFFICIENCY FACTOR    | 0.83   | 0.83                                                                       |
| J - OPERATOR WIDTH       | m      | 2.13                                                                       |
| L - ROLLOVER WIDTH       | m      | 0.20                                                                       |
| M - SERVICEABLE WIDTH    | m      | 1.93                                                                       |
| N - NUMBER OF PASSES     | un.    | 8.00                                                                       |
| O - DEPTH                | m      |                                                                            |
| P - FIXED TIME (LOADING, | m.in.  | 40                                                                         |
| UNLOADING, MANEUVERS)    |        |                                                                            |
| Q - GOING TIME           | m.in.  | 10                                                                         |
| R - RETURNING TIME       | m.in.  | 10                                                                         |
| S - TOTAL CICLE TIME     | m.in.  | 60                                                                         |
| T - GOING VELOCITY (MEAN)| m/m.in.| 70                                                                         |
| U - RETURNING VELOCITY   | m/m.in.| 500                                                                        |

### NOTES

<table>
<thead>
<tr>
<th>FORMULA</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P = \frac{D_x \times F \times M \times T}{N} )</td>
</tr>
<tr>
<td>( P = \frac{D_x \times F \times M \times T}{N} )</td>
</tr>
<tr>
<td>( P = \frac{D_x \times F \times M \times T}{N} )</td>
</tr>
<tr>
<td>Used to pull the harrow</td>
</tr>
<tr>
<td>( P = \frac{D_x \times B \times W \times C \times S} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment production rate (m³/h)</th>
<th>168</th>
<th>556</th>
<th>325</th>
<th>325</th>
<th>157</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Use</td>
<td>Operative</td>
<td>1.00</td>
<td>0.30</td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>Idle</td>
<td>0.00</td>
<td>0.70</td>
<td>0.48</td>
<td>0.48</td>
</tr>
</tbody>
</table>
FINDINGS

The SICRO system, despite being a good price reference for infrastructure works, presents in its methodology some weaknesses in relation to a good Cost Engineering practice, such as for example:

- Does not consider the opportunity capital cost for equipment
- Does not consider property costs for equipment in idle mode;
- Does not consider the additional labour cost for the equipment operators;
- Does not consider the additional labour burden fixed on union collective conventions;
- Does not consider railroad and waterway infrastructure services, because its highway origin;
- Uses the minimum coted price (equipment and materials), when the most correct would be an average or median;
- Lacks a clear definition of equipment idle and unproductive modes for use in the cost compositions;
- Lacks a clear definition of when local transport and commercial transport must be used;
- The factored crushed stone which is an good of intensive use in infrastructure works, has its cost underestimated in terms of used patterns of obtaining the stone, generating large differences in value between the factored crushed tone and the commercial crushed stone;
- For road enlargements and duplication, the SICRO methodology states that the rehabilitation efficiency factor must be used, but the by auditing and accountability offices do not fully accept these guidelines, resulting in lower prices and even contract changes.

In addition to these deficiencies in the original methodology, currently must be observed in the use of SICRO some undocumented changes, resulting from the interpretation of the methodology weakness by auditing and accountability offices, mainly the Federal Accounting Court (Tribunal de Contas da União – TCU) whose determinations have the strength of standard for Public Administration and often result in changes of prices and quantities in contracts, which may be cited as the main:

- Despite adopting the minimum coted price for input (equipment and materials), the SICRO reference must be used as a maximum reference value for estimate the construction budget;
- In contractual amendments the price to be adopted must be the smallest among prices of contract, prices of SICRO and market prices, being that the market price is not clearly defined and varies from analysis to analysis of the TCU;
- Prices of services not covered by SICRO to be used in projects budgets and in contractual amendments must be proposed within rigid rules and analysed by specific sectors of Public Administration;
- Some productivity losses admitted in theory by the SICRO methodology, like adverse weather, traffic interference and urban area interferences, are not fully accepted by auditing and accountability offices;
- Contract claims that not observe the SICRO methodology and its posterior auditing and accountability offices changes, usually are not accepted by the public administration.

Another point of constant changes is the BDI quotas, which despite having a theoretical freedom of adjustments in its components, in practice these adjustments are not made, fearing that the auditing and accountability offices may disagree with the proposed changes.
The main weaknesses of the BDI settlement are:

- Fixed value, as a percentage, for any type or size of project;
- Consider the plant overhead (field engineering and administration) as a percentage of direct cost, instead of pricing it;
- The main undocumented changes in BDI from the methodology by auditing and accountability offices are:
  - Some tax where considered not refundable and removed from the BDI;
  - The BDI over third party contractors and acquisition of expressive materials, like bituminous materials, where fixed at 15% over the direct cost;
- The BDI in contracts is not limited as the services prices are, if the overall price is equal to or less than the estimated by the Public Administration, i.e. if the BDI is greater, the direct costs must compulsorily be smaller than the estimated in the planned budget.

PRACTICAL IMPLICATIONS

By having to comply with the current legislation, the Federal Public Administration demands detailed pricing in bid proposals, made in accordance to SICRO methodology and a basis to the signed contract. But the need of update the SICRO methodology and the excessive regulation of auditing and accountability offices results in contracting projects with reference prices substantially distorted, based on market minimum prices and on imposed methodological changes. As these particularities and restrictions are often not observed in the preparation of bid proposals budgets, there is a great chance of posterior changes in contract already signed, forcing companies to reduce contract values or even return money paid for services already done.

Besides these contractual imposed changes, government engineers that are responsible for doing or analysing cost estimating, eventually suffers penalties that vary from monetary penalties to dismissal. Since 2006, some attempts have been done for improving the SICRO system, resulting in some versions with methodological changes that are still in discussion, but the perspective is a reference cost system in a closer compliance with the best practices of cost engineering.

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Establishment of Construction Unit Cost Factor Input Values for Kohonen architecture

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ABSTRACT

Purpose of this paper (mandatory)

The focus of this paper is the quantification of the eight cost factors established for the Zambian road sector using NeuroShell2 software. Derived input values for the cost factors were used in Kohonen network architecture to train the neural network.

Design/methodology/approach (mandatory)

To train a neural network, data has to be relayed through the input layer to the output layer. The input layer nodes are passive doing nothing but relaying values from their single inputs to their multiple outputs. Input can be numeric or text. Numeric data type was selected for easy input. Assumptions for the input values for eight identified qualitative cost factors in the Zambian road sector are presented and subjected to neural network prediction.

Findings and value (mandatory)

The neural network data patterns were analysed resulting in coefficients or cost estimating relationships of the factors. The coefficients were not constant but changed depending on the input value selection and combination of the factors.

Research limitations/implications (if applicable)

Limitations of the study included validity of the cost factors due to limited ranges of certain parameter input values.
Practical implications (if applicable)

The processed coefficients or weights were used to predict the indirect cost of a bill of quantities unit rate for roadworks. The results of the study could be integrated into a unit cost estimation model to develop engineers’ estimates.

Originality/value of paper (mandatory)

A number of studies on neural networks in cost estimating have focused on deriving conceptual estimates using back propagation. The study reported in this paper uses the Kohonen self organizing map network because it is unsupervised and has the ability to learn without being shown correct outputs in sample patterns.

Conclusions: It is hoped that the study will promote use of Kohonen network in predicting the indirect cost of infrastructure projects.

Keywords Unit cost estimation, neural network, Kohonen network, Zambian road sector

1 INTRODUCTION

Unit cost estimating, aided by sound engineering judgement, is the most definitive estimate technique and uses information down to the lowest level of detail available. Hendrickson (2008) described the unit cost estimation approach as where a unit cost is assigned to each task as represented by the bill of quantities and the total cost is the summation of the products of the quantities multiplied by the corresponding unit costs.

1.1 Cost estimation methods

AACE (2013) described parametric estimates as estimating algorithms or cost estimating relationships that are highly probabilistic in nature such that the parameters or quantification inputs into the algorithms tend to be abstractions of the scope. Typical parametric algorithms include, but are not limited to: factoring techniques; gross unit costs; and cost models that are algorithms intended to replicate the cost performance of a process of a system. Though Black (1984) stated that parametric estimating may mean different things to different researchers, the usual distinction from traditional estimating techniques seems to involve the use of aggregated systems in the estimates instead of building up the estimate from its components. Whereas parametric cost estimating methods often lead to a mathematically-fitted function called a cost estimating relationship (CER), non-parametric methods do not require CER. The parametric method of cost estimating uses statistical techniques such as regression analysis to find a functional relationship between changes in cost and the factors upon which the cost depends. A parametric model is a functional model that mathematically describes the cost of a structure, module, or a system as a function of one or more independent variables (de la Garza and Rouhana, 1995). Figure 2.3 indicates various types of cost estimating techniques used in the construction industry.
1.2 Neural networks

Neural networks are non-parametric. They are a form of artificial intelligence capable of capturing the relations between independent and dependent variables. Simply put a neural network consists of a minimum of three layers: an input layer; an output layer; and a hidden layer as shown in Figure 2.
One of the most important characteristics of neural networks is their ability to learn and self-organize (de la Garza and Rouhana, 1995). Neural networks similar to the regression analysis require the historical data of cost and data of variables influencing the cost. The neural network is trained with the historical data of the past projects so that it can capture the relations between variables and cost. The neural network is then used for cost estimation after training is completed.

2 LITERATURE REVIEW

There have been several citations from the literature on the use of neural network models to assist with cost estimation decisions in construction. Al-Tabtabai, et al. (1999) developed a neural network model that could be used to estimate the percentage increase in the cost of a typical highway project from a baseline reference estimate. Moselhi and Siqueira (1998) developed an automated cost estimating system for structural steel framing that provided quick cost estimates, and facilitated negotiations with owners and permitted the checking of detailed cost estimates prepared at a later stage. Work that specifically compares neural network to regression models for cost estimation includes material cost estimation of carbon steel pipes by de la Garza and Rouhana (1995) and the performance, stability and ease of cost estimation modelling to develop CERs by Smith and Manson (1997). In both studies, results showed that neural network were advantageous over parametric approaches.

Bode (1998) stated that neural network produce better cost predictions than conventional costing methods. He further said neural network do not require the relationship between attribute values and cost to be direct. In addition, neural network learn “from scratch” by detecting hidden relationships among training data. In contrast, parametric methods require the specification of a cost function type before its parameters are estimated. Neural networks outperform regression linear models given the same training data and the same variables (Setyawati et al., 2003). Artificial neural networks allow self-learning, self-organization, and parallel processing, and are well-suited for problems involving matching input patterns to a set of output patterns (Al-Tabtabai, et al, 1999). However, Moselhi and Siqueira (1998) noted that neural network also had their own shortcomings: they require in-depth technical knowledge in both the problem to be solved and in the development of neural network applications; are not transparent enough to provide explanation facility or rationale to the solution generated; and are sensitive to the organization and preparation of the data used in training. Nonetheless, in the last decade, neural networks have become powerful tools for investment forecasting and have achieved impressive results (Setyawati et al., 2003). Neural networks have been applied in financial forecasting, hotel industry applications, travelling problems, and environmental science applications. Setyawati et al. (2003) further stated that compared to traditional statistics, neural networks had been successful in many domains.

2.1. Neural network architecture

The selection of the neural network architecture was an important step to ensure that the model produced the least percentage error. Setyawati et al. (2003) stated that choosing the right neural network topology for use in a particular domain with optimum generalization performance was not a trivial problem. There was no fixed rule to determine the appropriate architecture or its parameter values.
2.1.1. Neural network design

From literature, one of the commercial software used for design and training of neural network model was NeuroShell2. NeuroShell2 was selected because of its classic neural network paradigms, its popularity amongst researchers and its user friendly graphical user interface (GUI) (Garson, 1998) NeuroShell2 has five network architectures that include different learning paradigms namely: Back propagation (BP); Kohonen; Probabilistic Neural Network (PNN); General Regression Neural Network (GRNN); and Group Method of Data Handling or Polynomial Nets (GMDH Network). All the networks are of supervised type, trained with both inputs and outputs except the Kohonen network.

A three layer back propagation neural network is the most effective for most applications (Ward Systems, 2014). This type of network was used in 95 percent of the working neural network applications and trained much faster than 4 or 5 layer networks (Ward Systems, 2014). A back propagation network called a recurrent network is excellent for time series data.

For sparse training data to be separated into categories, a Probabilistic Neural Network (PNN), known for its ability to train very quickly and work on sparse data is the most appropriate. Like PNN networks, General Regression Neural Networks are known for their ability to train quickly on sparse data sets. Ward Systems (2014) indicated that GRNN respond better than back propagation to many types of problems. The Kohonen Self Organizing Map is useful in clustering data. Because it is unsupervised, what is required is the number of desired categories.

Moselhi and Siqueira (1998) stated that back propagation is the training algorithm most commonly used for the development of civil engineering, and more specifically construction management applications. Setyawati et al., (2003) established that one hidden layer gave a lower percentage error than either two or three hidden layers. The number of hidden nodes that gave the best results was four and the lowest percentage error was obtained using 60 percent of the data as the training set. The tangent (tn) activation function gave better results than the sigmoid (sig) or linear activation functions.

2.1.2 Training Data

Neural networks are not programmed but trained (Setyawati et al. 2003). In order to be immediately useful, a neural network must be trained before actually being applied. Training is an estimation of a neural network model. The goal of the training process is to find the parameters of the neural network model, which are called connection strengths or network weights that reduce model errors. In general, there are two types of learning or training in a neural network: supervised and unsupervised.

a) Supervised

Supervised networks make predictions or decisions according to other patterns of inputs and outputs learnt. In a supervised network, the network learns how to make predictions, classifications, or decisions by giving it a large number of correct classifications or predictions from which it can learn. In supervised training both the inputs and outputs for a dataset are presented to the network during the learning process. Each processing unit receives a number of inputs, then each input is multiplied by a corresponding weight, and all the weighted inputs are then summed to determine the activation level of the processing
element. At the end of each cycle or iteration, the network evaluates the error between the desired output and actual output, and then uses this error to shift the connection weights according to a “learning rule” in what is generally referred to as back-propagation. For a certain number of learning cycles, the weights are shifted until the deviations from the desired outputs are minimized. Setyawati et al. (2003) established that the lowest percentage error was obtained using 60 percent of the data as the training set.

b) Unsupervised

Unsupervised networks classify a set of training patterns into a specified number of categories without being shown in advance how to categorize. The network uses clustering patterns. However, occasionally the network may not be able to separate the patterns into that many distinct categories (Ward systems, 2014).

3 METHODOLOGY

To train a neural network, data has to be relayed through the input layer to the output layer. The input layer nodes are passive doing nothing but relaying values from their single inputs to their multiple outputs (Smith, 1997). An input is a variable that a network uses to make a classification or prediction. It is sometimes referred to as an independent variable. Input can be numeric or text. Numeric data type was selected for easy input. The study focuses on the input node selection of the eight established cost factors for the Zambian road sector namely: contractor capacity; project location; period of honouring payments; project feasibility; escalation; material availability; country corruption profile; and political environment (Mwiya et al.). Contract documents for 254 projects were made available by the Road Development Agency (RDA). These projects were executed during a ten year period from 2005 to 2014. Data from these projects was used in the training of the neural network. Ward Systems (2014) the developer of neural network software, NeuroShell2, indicate that to train the network a good rule of thumb is the number of training patterns should equal 10 times the number of inputs. Therefore having the number of projects for training above eighty (80) was considered more than adequate.

3.1 Kohonen architecture

The Kohonen architecture was considered appropriate because it is unsupervised and has the ability to learn without being shown correct outputs in sample patterns. This network is able to separate data into a specified number of categories. The Kohonen Self Organizing Map network contains only two layers: input and output layers which have one neuron for each possible category. The eight factors with associated input nodes of 254 projects were fed into the neural network.

3.1.1 Training Criteria

a) Pattern Selection

Rotation as opposed to Random was used. Rotation selects training patterns in order and use when like training patterns are dispersed evenly through the training set (Ward Systems, 2014). Random chooses the training patterns randomly, although it does not guarantee that every pattern will be chosen an equal number of times. The random number generator usually does not select all of the patterns during
a single epoch, and will select some patterns multiple times (Ward Systems, 2014).

b) Distance Metric

Kohonen networks work by clustering patterns based on their distance from each other. In Vanilla or Euclidean distance metrics, the output of the network is the square of the distance between the pattern and the weight vector for that neuron, therefore the winner is the neuron with the minimum activation. Normalized takes arrays which are linear multiples of one another into the same normalized array. Normalized distance metrics were used as the values for all of the inputs were in the same range. Ward Systems (2014) advised against using normalized distance as it is not usually the preferred method.

c) Missing Values

Missing Values were set to be considered as error conditions as opposed to zeros or minimum values.

The selected training criteria are shown in Figure 3.

![Figure 3: Snapshot of Kohonen Training Criteria](image)

4 RESULTS AND DISCUSSION

4.1 Contractor capacity

Contractor capacity was determined by considering the National Council for Construction (NCC) contractor classification system. NCC categorises contractors in terms of technical capacity and area of specialisation. NCC Grades 1 to 6 consider contractors’ capacity where Grades 1 to 2 are large scale contractors, Grades 3 to 4 represent medium scale contractors and Grades 5 to 6 are entry level or small scale contractors. In terms of area of specialisation, NCC has 6 categories namely: General Building and Housing
(B); General Civil Engineering Works (C); General Roads and Earthworks (R); General Mining Services (M); Electrical and Telecommunications (E); and Specialised work (S). The focus of the study was contractors in the R category. Therefore the derived input nodes for contractor capacity were: 1 = Grade 1; 2 = Grade 2; 3 = Grade 3; 4 = Grade 4; 5 = Grade 5; 6 = Grade 6; and 7 = ungraded.

4.2 Project location

Project location was estimated as approximate distance of the project from the capital city, Lusaka. GRZ (2014) on the Zambia distance table calculates the most practical and not necessarily the shortest routes. The Zambia distance table showed that the furthest distance between any two towns was 1772 km from Lundazi to Mbala. But the furthest from Lusaka, which is centrally located, was 1016 km to Mbala. Project location was calculated from Lusaka because it was a general practice that contractors mobilised from Lusaka. This assumption was confirmed after analysing the project details obtained which indicated that about 92 percent of the contractors in R category mobilised from Lusaka. From the form of agreement signed, all these contractors indicated that their registered company addresses were in Lusaka. Therefore the derived input nodes for project location were: 1 = very near (<100km); 2 = near (101-300km); 3 = average (301-500km); 4 = far (501-700km); 5 = very far (701-900km); and 6 = extremely far >901km.

4.3 Period of honouring payments

The sampled contracts indicated the period of honouring payments in the general conditions of contract varied between 28 and 84 days after the Engineer receives the statement and supporting documents. The contractor therefore has to factor costs for that period. Therefore the derived input nodes for period of honouring payments were: 1 = up to 28 days; 2 = up to 35 days; 3 = up to 42 days; 4 = up to 49 days; 5 = up to 56 days; 6 = up to 63 days; 7 = up to 70 days; 8 = up to 77 days; and 9 = up to 84 days.

4.4 Project feasibility (pre-construction)

In factor analysis, the variables that were grouped to form the factor named project feasibility were: Project_Scope; Contract_Financing; Project_Planning; and Project_Need. The major concern under project feasibility was the tendency of appointing consultants after awarding works to the main contractor. From expert intuition and in consultation with the public roads agency RDA, the factor was changed to “Level of design” with four (4) input nodes: 1 = very good – detailed design available (prepared by a consultant); 2 = good – preliminary design prepared by consultant; 3 = satisfactory – preliminary design prepared by client (RDA) to be reviewed by consultant; and 4 = Poor – sketch designs available.

4.5 Cost escalation

Escalation may include general inflation related to the money supply, but it is primarily specific to labour, material and machinery price trends. It covers the potential increase in cost of the project’s inputs. Figure 4 shows the trend for general inflation, consumer price index and cement prices from 2009 to 2014.
For the period 2009 to 2014 the average annual general inflation was 8.24 percent. The average annual consumer price index was 19.67 in the same period. The cement prices escalation was 8.7 percent. Figure 5 shows Zambia ex-factory price trend for the three players in the cement production sector.
Mbongwe et al (2014) noted that Zambia’s prices remained above those of the other countries as shown in Figure 6.
The international comparisons show that Zambian ex-factory prices were substantially higher than in other countries over the period, and at times close to double those in South Africa, the lowest priced country. The trend is the same when considering fuel. Table 7 shows the gasoline retail prices in SADC in US cents per litre for selected years (SADC, 2012).

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>38.0</td>
<td>30.0</td>
<td>19.0</td>
<td>39.0</td>
<td>50.0</td>
<td>53.0</td>
<td>65.0</td>
<td></td>
<td></td>
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<tr>
<td>Botswana</td>
<td>68.0</td>
<td>41.0</td>
<td>38.0</td>
<td>31.0</td>
<td>42.0</td>
<td>41.0</td>
<td>66.0</td>
<td>78.0</td>
<td>88.0</td>
<td>93.0</td>
</tr>
<tr>
<td>Democratic Republic of Congo</td>
<td>81.0</td>
<td>74.0</td>
<td>73.0</td>
<td>50.0</td>
<td>100.0</td>
<td>70.0</td>
<td>92.0</td>
<td>94.0</td>
<td>123.0</td>
<td></td>
</tr>
<tr>
<td>Lesotho</td>
<td></td>
<td></td>
<td>39.0</td>
<td>50.0</td>
<td>73.0</td>
<td>89.0</td>
<td>79.0</td>
<td>97.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Madagascar</td>
<td>43.0</td>
<td>54.0</td>
<td>47.0</td>
<td>47.0</td>
<td>76.0</td>
<td>108.0</td>
<td>105.0</td>
<td>115.0</td>
<td>155.0</td>
<td>152.0</td>
</tr>
<tr>
<td>Malawi</td>
<td>64.0</td>
<td>71.0</td>
<td>65.0</td>
<td>51.0</td>
<td>69.0</td>
<td>66.0</td>
<td>95.0</td>
<td>117.0</td>
<td>178.0</td>
<td>171.0</td>
</tr>
<tr>
<td>Mauritius</td>
<td>55.7</td>
<td>55.1</td>
<td>67.2</td>
<td>83.2</td>
<td>115.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>142.7</td>
</tr>
<tr>
<td>Mozambique</td>
<td>74.0</td>
<td>48.0</td>
<td>53.0</td>
<td>55.0</td>
<td>56.0</td>
<td>46.0</td>
<td>88.0</td>
<td>115.0</td>
<td>171.0</td>
<td>111.0</td>
</tr>
<tr>
<td>Namibia</td>
<td>46.0</td>
<td>42.0</td>
<td>38.0</td>
<td>47.0</td>
<td>45.0</td>
<td>68.0</td>
<td>87.0</td>
<td>78.0</td>
<td>106.0</td>
<td></td>
</tr>
<tr>
<td>Seychelles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>135.0</td>
</tr>
<tr>
<td>South Africa</td>
<td>52.0</td>
<td>51.0</td>
<td>43.0</td>
<td>50.0</td>
<td>43.0</td>
<td>81.0</td>
<td>85.0</td>
<td>65.0</td>
<td>119.0</td>
<td></td>
</tr>
<tr>
<td>Swaziland</td>
<td>46.0</td>
<td>43.0</td>
<td>37.0</td>
<td>47.0</td>
<td>76.0</td>
<td>80.0</td>
<td>86.0</td>
<td>107.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>42.0</td>
<td>43.0</td>
<td>56.0</td>
<td>63.0</td>
<td>75.0</td>
<td>67.0</td>
<td>93.0</td>
<td>104.0</td>
<td>111.0</td>
<td>122.0</td>
</tr>
<tr>
<td>Zambia</td>
<td>40.0</td>
<td>72.0</td>
<td>60.0</td>
<td>53.0</td>
<td>72.0</td>
<td>110.0</td>
<td>131.0</td>
<td>170.0</td>
<td>166.0</td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>68.0</td>
<td>47.0</td>
<td>38.0</td>
<td>26.0</td>
<td>85.0</td>
<td>5.0</td>
<td>61.0</td>
<td>130.0</td>
<td>129.0</td>
<td></td>
</tr>
</tbody>
</table>

From Table 7 the price of gasoline for Zambia moved from the lowest in 1991 at US$ 0.40 to the highest at US$ 1.66 per litre in 2010, second only to Malawi. The assumption therefore is that the unit rates of the Zambian road sector were expected to be higher than those in the region.

The Zambian road sector uses the consumer price index for price adjustments for contracts longer than 18 months. Clearly this practice is not appropriate and construction specific indices need to be developed to determine the level of escalation.

Nonetheless, the derived input nodes for cost escalation were: 1 = 0 percent; 2 = 5 percent; 3 = 10 percent; 4 = 15 percent; 5 = 20 percent; 6 = 25 percent; 7 = 30 percent; and 8 = above 35 percent

4.6 Materials availability

The Zambian road sector has both local and imported materials. Materials availability has been stable. The last severe construction shortage was in the mid-eighties at the time of auctioning for foreign exchange. The kwacha, the Zambian currency, quickly depreciated from K2.2/dollar to K6/dollar affecting imports (Bates and Collier, 1994). Materials available locally means that both imported and local materials were available. Available internationally means that there were restrictions on importing material
into the country. Shortage means the local materials were scarce locally but available internationally and severe shortage means materials were not available both locally and internationally. Therefore the derived input nodes for material availability were 1 = available locally; 2 = available imported; 3 = shortages; and 4 = severe shortages.

### 4.7 Country corruption profile

Corruption perception index (CPI1) is a ranking of countries according to the extent to which corruption is believed to exist. The corruption perception index was created in 1995 by Transparency International. Zambia was only profiled from 1998 onwards. The derived input nodes for country corruption profile based on compilation by Transparency International were: 1 = very clean (100 to 80), 2 = clean (79 to 60), 3 = moderate (59 to 40), 4 = corrupt (39 to 20), 5 = highly corrupt (19 to 0)

### 4.8 Political environment

The country political environment relates to political interference as perceived by stakeholders. The transfer of RDA to the Office of the President in 2011 was perceived as increased political risk. The relationship between the government and foreign contractors was also considered as a political risk.

Multilateral Investment Guarantee Agency (2014), amongst its findings, indicated that political risk ranked in fourth place out of twenty in terms of its difficulty to forecast. To introduce objectivity to this factor, the Worldwide Governance Indicators (WGI) were considered. Governance consists of the traditions and institutions by which authority in a country is exercised (World Bank, 2014). It includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them (World Bank, 2014). In other words governance refers to a political environment of a country. The WGI project aggregated individual governance indicators for 215 economies over the period 1996 to 2013 for six dimensions of governance namely:

- Voice and Accountability;
- Political Stability and Absence of Violence;
- Government Effectiveness;
- Regulatory Quality;
- Rule of Law; and
- Control of Corruption.

The percentile rank from 0 to 100, with higher values corresponding to better outcomes, has been used. Figure 8 shows Zambia’s percentile rank of the six WGI.
Figure 8 shows that though Zambia's stability is good, government effectiveness is poor. The average scores for all six WGI place Zambia below 50 percent in the 25 to 50 percentile range. In summary, the political environment considered the governance structures, regulation and level of political influence in the running of the Zambian road sector. The derived input nodes based on political interference in road projects were: 1=none; 2= low; 3= moderate; 4= high; and 5= very high.

The input nodes for the eight factors used in the study are shown in Table 9.
Table 9: Established factors and associated input nodes

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Cost factor</th>
<th>Factor Input for neural network</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contractor capacity</td>
<td>Capacity of contractor 1 = Grade 1, 2 = Grade 2, 3 = Grade 3, 4 = Grade 4, 5 = Grade 5, 6 = Grade 6, 7 = ungraded</td>
</tr>
<tr>
<td>2</td>
<td>Project Location</td>
<td>Distance in km from Lusaka or urban location 1 = very near (&lt;100km), 2 = near (101-300km), 3 = average (301-500km), 4 = far (501-700km), 5 = very far (701-900km), 6 = extremely far &gt;901km</td>
</tr>
<tr>
<td>3</td>
<td>Period of honouring payments</td>
<td>1= up to 28 days; 2= up to 35 days; 3 = up to 42 days; 4= up to 49 days; 5= up to 56 days; 6= up to 63 days; 7= up to 70 days; 8= up to 77 days; and 9= up to 84 days</td>
</tr>
<tr>
<td>4</td>
<td>Level of design</td>
<td>1= very good, 2=good, 3= satisfactory, and 4= poor</td>
</tr>
<tr>
<td>5</td>
<td>Escalation</td>
<td>1 = 0%, 2 = 5%, 3 = 10%, 4 = 15%, 5 = 20%, 6 = 25%, 7 = 30%, 8 = above 35%</td>
</tr>
<tr>
<td>6</td>
<td>Materials availability</td>
<td>1 = available locally, 2 = available imported, 3 = shortages, 4= severe shortages</td>
</tr>
<tr>
<td>7</td>
<td>Country corruption profile</td>
<td>CPI1 compiled by Transparency International 1=very clean (100-80), 2= clean (79-60), 3= moderate (59-40), 4= corrupt (39-20), 5= highly corrupt (19-0)</td>
</tr>
<tr>
<td>8</td>
<td>Political environment</td>
<td>Political interference 1=none, 2= low, 3= moderate, 4= high, 5= very high</td>
</tr>
</tbody>
</table>

4.9 Calculation of project factor input

Contractor capacity was obtained from the NCC registration certificate in the tender documents. The input for this factor from the projects analysed is shown in Figure 10.
The results from Figure 10 are consistent with the practice in the Zambian road sector where contractors registered in Grade 1 carry out major roadworks.

For project location the input data is shown in Table 11.

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Input Description</th>
<th>Project totals in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1= very near</td>
<td>4%</td>
</tr>
<tr>
<td>2</td>
<td>2= near</td>
<td>16%</td>
</tr>
<tr>
<td>3</td>
<td>3= average</td>
<td>24%</td>
</tr>
<tr>
<td>4</td>
<td>4= far</td>
<td>28%</td>
</tr>
<tr>
<td>5</td>
<td>5= very far</td>
<td>24%</td>
</tr>
<tr>
<td>6</td>
<td>6= extremely far</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 11 indicates that majority of the projects about 52 percent are located between 500 to 900km from contractor registered office. This entails that mobilisation and demobilisation costs are a major factor.

Periods of honouring payments were obtained from special conditions of contract. If nothing was specified, then 1 = up to 28 days was used as this was the standard practice. The input data for period of honouring payments is shown in Table 12.

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Input Description</th>
<th>Project totals in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1= up to 28 days</td>
<td>60%</td>
</tr>
<tr>
<td>2</td>
<td>2= up to 35 days</td>
<td>36%</td>
</tr>
<tr>
<td>3</td>
<td>3 = up to 42 days</td>
<td>0%</td>
</tr>
<tr>
<td>4</td>
<td>4= up to 49 days</td>
<td>0%</td>
</tr>
<tr>
<td>5</td>
<td>5= up to 56 days</td>
<td>0%</td>
</tr>
<tr>
<td>6</td>
<td>6= up to 63 days</td>
<td>0%</td>
</tr>
<tr>
<td>7</td>
<td>7= up to 70 days</td>
<td>0%</td>
</tr>
<tr>
<td>8</td>
<td>8= up to 77 days</td>
<td>0%</td>
</tr>
<tr>
<td>9</td>
<td>9= up to 84 days</td>
<td>4%</td>
</tr>
</tbody>
</table>
Results from Table 12 show that majority of the projects did not have the period of honouring payments stated in the contracts.

Level of design considered level of detailed design available. The breakdown of the input data is shown in Figure 13.

Figure 13: Breakdown of level of design data input

From figure 13, information on 20 percent of the projects was not clear and therefore could not be used in the training.

The consumer price index was used in the determination of the input nodes for escalation at 2009 weights. Input data for escalation is shown in Table 14.

Table 14: Input data for escalation

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Input Description</th>
<th>Project totals in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 = 0%</td>
<td>32%</td>
</tr>
<tr>
<td>2</td>
<td>2 = 5%</td>
<td>0%</td>
</tr>
<tr>
<td>3</td>
<td>3 = 10%</td>
<td>12%</td>
</tr>
<tr>
<td>4</td>
<td>4 = 15%</td>
<td>8%</td>
</tr>
<tr>
<td>5</td>
<td>5 = 20%</td>
<td>32%</td>
</tr>
<tr>
<td>6</td>
<td>6 = 25%</td>
<td>0%</td>
</tr>
<tr>
<td>7</td>
<td>7 = 30%</td>
<td>4%</td>
</tr>
<tr>
<td>8</td>
<td>8 = above 35%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Table 14 indicates that the escalation cost for the projects was somewhere around 20 percent.

Input for materials availability was 1 indicating available locally for all projects.

The input for the country corruption profile factor was 4 indicating corrupt for all projects.
Political environment input is shown in Figure 15.

Figure 15: Breakdown of the political environment input nodes

He input for political environment were based on the assumption that projects commenced before 2011 were rated as moderate and those with a start date after 2011 were categorised as having high political interference. Of the eight factors, this was the most subjective and further studies would be required to quantify the risk for the Zambian scenario.

4.10 Neural network output

The output from the trained network produced weights depending on the input parameters selected. The weights represent the cost estimating relationships between the eight factors. The neural network output depends on the selection made for each factor. These are not constant and the weights changes depending on the selected input parameters of the factors. An example of the neural network output weights is shown in Figure 16.
Figure 16: Snapshot of input and output parameters

From the trained data, the software has a provision for source code generation. The generated source code was incorporated into a unit cost estimation model.

5 CONCLUSION

The study presented how the assumptions and ranges of the input values for the eight cost factors for the Zambian road sector namely: contractor capacity; project location; period of honouring payments; level of design; escalation; material availability; country corruption profile; and political environment were derived. Of the eight qualitative factors, political environment was the least objective. Details of the neural network architecture used and training criteria adopted were outlined. The output weights provided a cost estimating relationships of the factors which could be adopted to quantify the qualitative indirect cost of unit rates of roadworks in the Zambian road sector.

6 References


Government of the Republic of Zambia (GRZ) (2014), Zambia Distance Table Government Printers, Zambia


Audit: A Path to Project Performance

Dr. Alexia Nalewaik FRICS CCP CCA

FRAMING THE PROBLEM

The world of projects
- Projects are often unique, complex, complicated, dynamic
- Projects rely on people
- Change is a constant
- Different stakeholders have different definitions of success
- Risk exists

Project Management tools
- There are many different philosophies and methodologies for ‘successful’ project management... but there are no guarantees
- Following detailed project management and project controls policies and procedures does not mean a project will be successful... they are a best practice, and do contribute to improved chances of project success
- There are many variables in projects and project management that are difficult to capture... especially the ‘people’ part

ABOUT PERFORMANCE AUDIT

Project Audit
- One of the most common statutory and regulatory oversight mechanisms required on projects is audit
- When most people think of audit, financial audit comes to mind
  - Financial auditing focuses on accounting and fiscal regularity
Expenditure audit focuses on where and how funds were spent, with a strong focus on compliance.

- Performance evaluation grew from financial auditing, amidst concerns that adequate accounting, controls, and compliance were not sufficient to guarantee success.

**Performance Audit**

- The objectives of performance review are continuous improvement and stakeholder assurance.
- Projects, departments, and entire organizations can be evaluated.
- A performance audit examines the process by which an entity is achieving its objective:
  - Economy – undertaking the work with least wastage of physical and financial resources (inputs)
  - Efficiency – performing work productively, with a high ratio of inputs to outputs
  - Effectiveness – extent to which business and stakeholder objectives are met (outputs)
- Client experiences:
  - Audits of the same entity (performed in different years or at a different point in the project lifecycle) did not use the same methodologies or achieve the same depth, even if the teams came from the same consulting firm.
  - There was often a difference between scope and stakeholder groups' perception of the audit function (expectations gap).
  - Almost anything can be called a 'performance audit'.
  - Most audits generated findings that focused on compliance, not performance.
- Resolution of performance review findings is imperative:
  - No change means no improvement.

**PROCURING AUDIT SERVICES**

**Procuring services and teams**

- Defining the audit scope is the most important part of procurement.
- Different kinds of audit (scope) yield different types of findings.
SCOPING PROJECT PERFORMANCE REVIEWS

Flexible and Modular Approach

- Adaptable to organizations, projects, programs, and portfolios of any size
  - Different industries, such as: construction, manufacturing, IT, and major events
  - Any sector, such as: education, healthcare, utilities, petrochemical, pharmaceutical, commercial, etc.
  - Any country, state, county, city, agency
- Might not always need to scope all modules
  - Not a highly prescriptive template or checklist
  - Flexible and responsive to the dynamics, uniqueness, and risks of the project and organization
- Compliant with all regulatory requirements and audit standards
- Review scope can be fine-tuned to address the specific needs of the project
  - Directs team resources to areas that can benefit the most
  - Tailored to the specific needs of the project at key milestones in the project lifecycle
  - Focus on obtaining value and return on investment from the review process

<table>
<thead>
<tr>
<th>Type of Finding</th>
<th>Expenditure Audit</th>
<th>Performance Audit</th>
<th>Risk / Assurance Method</th>
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</thead>
<tbody>
<tr>
<td>Lack of Expenditure Support</td>
<td>23.28%</td>
<td>1.03%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Incorrect Math</td>
<td>1.32%</td>
<td>0.26%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Contract Compliance</td>
<td>32.01%</td>
<td>1.79%</td>
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<tr>
<td>Incorrect Rates</td>
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<td>Excessive or Unallowable Charges</td>
<td>27.25%</td>
<td>2.31%</td>
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<td>Duplicated Scope of Work or Payment</td>
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<td>0.51%</td>
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<tr>
<td>Inadequate Controls or Accounting</td>
<td>7.41%</td>
<td>11.79%</td>
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<tr>
<td>Program Management Best Practices</td>
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<td>23.33%</td>
<td>28.57%</td>
</tr>
<tr>
<td>No issues</td>
<td>33.86%</td>
<td>72.56%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
• Process is iterative, and should be repeated (and re-scoped) at the next major project milestone

• Risk-based methodology includes evaluation of any activity that consumes program resources

**Standards**

• Designed to comply with extant regulatory requirements and audit standards, where mandated

• ISO 19011 – Review of Management Systems
  ◊ Trust
  ◊ Integrity
  ◊ Confidentiality
  ◊ Discretion
  ◊ Ethical conduct
  ◊ Fair presentation
  ◊ Due professional care
  ◊ Independence
  ◊ Experience
  ◊ Evidence-based approach
  ◊ Continuous improvement
  ◊ Recordkeeping
  ◊ Follow-up and resolution

**Audit Objectives**

• Facilitate continuous improvement
• Support a learning culture
• Provide assurance to stakeholders
• Ensure accountability
• Strengthen controls
• Enable transparency in reporting
• Contribute to good governance
• Empower critical questioning
• Provide external validation, not biased self-assessment
• Create a culture of best-for-project decision-making
- Cost-benefit (cost of review vs. value provided)
- Focus on leading measures instead of lagging measures

**NALEWAIK - MILLS PERFORMANCE REVIEW MODE**

**QA/QC Modules**

1. Project Planning: Matching objectives with long-term strategy
2. Stakeholder Identification: Defining success
3. Risk Assessment: Optimizing opportunities
4. Compliance: Responding to internal and external requirements
5. Resource Analysis: Focusing on economy and efficiency
6. Management Controls: Improving effectiveness
7. Post-Project Concerns: Customer satisfaction and future planning
8. Special Issues: Targeted review of specific concerns and risks

**Module 1 – Project Planning**

- Intended to address the politics and challenges of project approval
  - Gap between project needs and available funding
  - Design for success
- Review of the project initiation process
  - Project objectives / organizational strategic objectives
  - Financing model, cash flow
  - ROI, operating costs, value for money
  - Development of scope, specifications, and requirements
  - Asset planning
  - Contracting and procurement mechanisms
  - Project organization structure and team
Module 2 – Stakeholder Identification

- Definition of success depends on stakeholders
- Multiple levels of stakeholders and their influence create a network of interdependencies and obligations within the project hierarchy
- Identify and understand stakeholders
  - Levels of interest and influence
  - Definitions of success and concepts of value
  - Motivations of profit, power, and achievement
  - Level of tolerance for risk and change
- Know the project audience
  - Design communication plans to address them accordingly

Module 3 – Risk Assessment

- Project reviews are limited by constraints of politics, cost, and time
- Assessing risks enables project reviews to be focused for best results
- Identify risks, and prioritize them based on probability and impact
- Develop a risk management and mitigation plan
- Repeat

Identifying risks

- Risk quantification tends not to focus on extreme-impact statistically-unlikely events such as:
  - War, terrorism, political instability, corruption, earthquake, tsunami, stock market crash
  - Extreme operational risks of the type discussed in Basel II (et seq.)
  - Space alien invasion, zombie apocalypse
Project risks (partial list)

- Technical Risk
  ◊ proven/unproven technology
  ◊ implementation methodology
  ◊ equipment & material performance
  ◊ planning & design complexity
  ◊ commissioning & testing
  ◊ evolving requirements

- Financial, economic, political risk
  ◊ inflation
  ◊ funding/financing
  ◊ market forces
  ◊ local law or government policy
  ◊ labor & material costs or availability
  ◊ interest rate
  ◊ regulatory exposures

- Organizational & contractual risk
  ◊ project team capability
  ◊ contractual liability
  ◊ contractor failure
  ◊ mergers & acquisitions
  ◊ warranties
  ◊ liquidated/punitive damages
  ◊ staff and stakeholder turnover

- Other risks
  ◊ location
  ◊ tie-in to existing project
  ◊ phasing
  ◊ safety
  ◊ unknown conditions
  ◊ external influence
  ◊ reputation
- Statutory risk
  - environmental & government clearance
  - property acquisition
  - permitting

Module 4 - Compliance

- Why test for compliance?
  - Legislative or regulatory requirement for evaluation of compliance
  - Stakeholder concerns about compliance with internal policies or contract
  - Noncompliance with policies & procedures may identify opportunities for improvements or streamlining of procedures

Module 5 – Resource Analysis

- Any and every activity that consumes project resources has the potential to be evaluated

- Critical questioning of why things are done a certain way, in order to reduce risk, increase value to stakeholders, and assure performance

- Focus on the best and most appropriate use of resources: cost, schedule, people, departments, materials, equipment, IT systems, tools, etc
  - Overlaps, overburdening, and gaps in available resources may be identified, creating opportunities for reallocation and streamlining of resources.

Module 6 – Management Controls

- Reviews project management and related processes, goal is appropriateness for the project
  - Total Cost Management (www.aacei.org) and quality assurance
  - Other areas of review: environmental sustainability, change management, procurement and contracting, project controls, accounting, safety, product quality, document control, commissioning, and data management
  - Softer elements: lessons learned, decision-making processes, levels of authority, ethics and conflicts of interest, innovation, training, communication, and reporting

Module 7 – Post-Project Concerns

- Projects create products that live on beyond the project lifecycle, and have a lifecycle of their own
◊ Maintenance and operations of the project product
◊ Asset management, capitalization & depreciation
◊ Funds accounting
◊ Customer satisfaction
◊ Future market conditions
◊ Lessons learned
◊ Product performance
◊ Historical data and benchmarks

Module 8 – Special Issues

- Other concerns that require consideration and were not included above, but which would not be conducted as a separate engagement

- YES
  ◊ Forensic review
  ◊ Special issues (systems, departments)
  ◊ Expenditure review
  ◊ Resolution of previously identified audit issues
  ◊ Building performance

- NO
  ◊ Financial audit
  ◊ Value engineering
  ◊ Technical reviews
  ◊ Inspector general investigation
  ◊ Monte-Carlo style risk modeling
  ◊ Claims analysis
  ◊ LEED / BREEAM
EXAMPLES

Project QA/QC Review Modules

- Gas and electric utility
  - Major regional program to upgrade all assets

- Issues
  - New delivery method (alliance contracts)
  - Want to standardize project review
  - Need to close out projects

- Largest school district in the country
  - Knew they had monies in contingency & reserves for old projects
  - Wanted to fund new projects
Issues

◊ Quantify needed contingency and reserves

Module 3 RISK ASSESSMENT: Optimizing opportunities

◊ Formalize processes

Module 6 MANAGEMENT CONTROLS: Improving effectiveness

Module 7 POST-PROJECT CONCERNS: Customer satisfaction and future planning

◊ Find existing contingency, reserves, & other monies

Module 8 SPECIAL ISSUES: Targeted review of specific concerns and risks

Module 4 COMPLIANCE: Responding to internal and external requirements

Major transportation agency

◊ Bids received were over budget

Issues

◊ Estimating

Module 4 COMPLIANCE: Responding to internal and external requirements

Module 5 RESOURCE ANALYSIS: Focusing on economy and efficiency

Module 6 MANAGEMENT CONTROLS: Improving effectiveness

◊ Budget

Module 1 PLANNING: Matching objectives with long-term strategy

◊ Stakeholders

Module 2 STAKEHOLDER IDENTIFICATION: Defining success

◊ Contingency

Module 3 RISK ASSESSMENT: Optimizing opportunities
• **Infrastructure project with global impact**
  ◊ Client wanted to develop a five year audit plan
  ◊ Performance review done at the time of bid award

• **Issues**
  ◊ **Risk**

  ![Module 3: Risk Assessment: Optimizing opportunities]

  ![Module 6: Management Controls: Improving effectiveness]

  ![Module 5: Resource Analysis: Focusing on economy and efficiency]

  ◊ **Governance**

  ![Module 8: Special Issues: Targeted review of specific concerns and risks]

  ◊ **Additional concerns**

  ![Module 3: Risk Assessment: Optimizing opportunities]

• **$1 Billion PPP, constructing a University**
  ◊ Focus on continuous monitoring

• **Issues**
  ◊ **Risk**

  ![Module 3: Risk Assessment: Optimizing opportunities]

  ◊ **Governance**

  ![Module 6: Management Controls: Improving effectiveness]

  ![Module 5: Resource Analysis: Focusing on economy and efficiency]

  ◊ **Success**

  ![Module 4: Compliance: Responding to internal and external requirements]

  ![Module 7: Post-Project Concerns: Customer satisfaction and future planning]

  ![Module 8: Special Issues: Targeted review of specific concerns and risks]
THE BOOK

- Project Performance Review: Capturing the Value of Audit, Oversight, and Compliance for Project Success

- Nalewaik & Mills
  - Routledge / Taylor & Francis website
    - US$70 hardcover, US$15 e-book
    - https://www.routledge.com
  - Amazon.com
    - US$70 hardcover, US$15 e-book
    - www.amazon.com
Claims and Disputes in the Construction Industry

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ABSTRACT

Purpose of this paper

This paper looks at claims and disputes in the construction industry. It attempts to determine the main causes of these claims, and what causes them to become disputes. The paper will in addition look at alternatives for avoiding claims and disputes. This will be done by closely observing the common claims that usually take place and thus, turn into disputes.

Design/methodology/approach

This research paper is based on current real case studies/scenarios related to Claims and Disputes using Fidic Contracts from the expert Claims Consultants. The interview Questionnaire is also prepared for Engineer, Employer and the Contractor on their views for what causes these Claims and Disputes.

Findings and value

While most common Claims and Disputes are related to Extension of Time (EOT) on delays. Fidic Contracts do not define how delay and related costs should be calculated. Concurrent delays normally cause problems in Delay Analysis. Claims preparation procedure is not established between the Contractor and the Engineer.

Practical implications

Most claims and disputes are attributable to different factors such as increased labour costs, strikes, cost underestimates and weather conditions. Some are clearly projected or are expected, whereas others branch from uncertainties and unforeseen events. It is difficult to be completely prepared for these claims, as some of these factors occur concurrent, thus also inflexible to retain constant at dealing, as well as avoiding them.
Originality/value of paper

This paper is based on recent real cases of claims and disputes. These cases are from the international expert consultants, who were put together to help the Capital Project Employer to resolve claims and disputes arising from the Fidic Engineer and the Contractor.

Conclusion:

Front end tasks should be established to minimise the claims and disputes arising from construction contracts. These include reviewing contract documents to remove ambiguities. Claims and Disputes are formed from "gray" areas in contract documents. Special conditions of contract must be drafted by experts trained to resolve disputes. Execution stage of a project should employ sound contract administration/management procedures to help a project team successfully defend/win claims and avoid disputes.

Keywords: Claims, Disputes, Contracts, Extension of time

1 INTRODUCTION

Many South African private and public construction projects are experiencing severe cost overruns and delays, which inevitably lead to claims by contractors for a revised or extended completion date and for the payment of additional and associated costs.

Contractors submit these claims to employers to recover losses and extra expenses. These losses and expenses are attributable to factors such as increased labour costs, strikes, cost underestimates and weather conditions. Some are clearly foreseeable or are expected, whereas others stem from uncertainties and unexpected events. These claims are, unfortunately, still viewed as negative by employers, it is regrettable that claims have acquired this negative connotation. This negative perception exists, as many contractors abuse the claims processes to recover losses and extra expenses, which often occurs as a result of their own fault or poor performance.

Claims are simply part of the process of dealing with risks that materialise during a project’s execution. Secondly, contractors cannot generally claim anything which the contract – and, hence, the employer – does not specifically allow him or her to claim. Claims are thus the outcome of the manner in which the parties (in many instances, it is only the employer) allocate and assign risk.

But claims, disputes and contractual issues are becoming more frequent, owing to relatively low profit margins and scarce work opportunities and resources, noting that having a good understanding of one’s contract and the rights and obligations of the parties involved, as well as the procedures applicable to notices and claims, is becoming an essential and indispensable business tool. Construction law and claim consultants assist with these claims processes and help companies to avoid disputes to save management and time costs.

It is equally important to have a thorough understanding of the claim procedures and processes set out in the various construction contracts to avoid the submission of spurious or poor claim.
Owing to many claims failing and the subsequent disputes and general unhappiness in the industry, contractors and employers have made renewed attempts to better understand the types of contracts being used.

2 TYPES of claims

A claim may not necessary lead to a dispute. Most of the contractual claims are either extension of time claims or monetary claims and are settled during the contract period or at the settlement of final account stage.

It is only in those cases where the contractor has submitted and insisted a highly inflated or totally fictitious claim, and then a dispute will follow.

In this paper, we will be discussing claims most related to FIDIC conditions, as it is the most internationally used form of Contract

Papworth, J summarized FIDIC and divided its claims as follows:

- Claims for extension of time
- Claims for payment

1.1 Claims for extension of time

Contractor’s Basic Entitlement

The Contractor is entitled to claim an extension of time according to the Clause 8.4. Contractor can show where he has been delayed by reasons beyond his control. If the Contractor obtains an extension of time, he may be in a position to recover his time-related costs of remaining on site longer.

Assessment of Delay

The Clause can be activated when the Contractor suffers delay, or will be delayed.

The only realistic way of assessing delay is by comparison with the Clause 8.3 programme. If the programme is of sufficient quality, it should form a good basis for assessing delays.

Grounds for Extensions of Time

The possible grounds for an extension of time are:

- Variations
- A cause of delay referred to in the Conditions in clauses
- Exceptionally adverse climatic conditions
- Unforeseeable shortages of personnel or Goods, caused by epidemics or governments
A delay caused by the Employer or a party under his control

Unforeseeable Physical Conditions

Physical conditions are defined as ‘natural physical conditions and man-made and other physical obstructions and pollutants’. According to the definition in Clause 1.1.6.8, the criterion for judging what is unforeseeable is what is ‘not reasonably foreseeable by an experienced contractor by the date for submission of the Tender’.

Full Supporting Particulars: Basic Requirements

The Contractor is to provide full supporting details of his application within 42 days of the occurrence of the delaying event. In practice, it will be difficult for the Contractor to produce full supporting particulars within 42 days, especially if the project has been underway for some time, and is complex. This makes continuous keeping of good records, and the rapid compilation of the claim, imperative. In reality, the quality of details varies considerably.

Some claims are simply not detailed, and some are not even particularized. That type of claim does not deserve success. The basic requirement is for the claim to be particularised. If there are several different causes of delay, a period of delay should be attributed to each cause.

That is the basic requirement of linking cause and effect. If there is concurrent delay, then the Contractor needs to say so. He then needs to decide which delay, if any, caused more overall delay. In order to do this, the Contractor will have to go through and produce factual evidence. It is a discipline, which will help him put his case, and helps the Engineer follow and understand his arguments. The particulars should reasonably include correspondence, meeting minutes and other documents.

Full Supporting Particulars: Presentation

However, the mere inclusion of hundreds of sheets of photocopied letters and other documents will not get the claim home on their own. There has to be some narrative, which refers to the documents, and then draws some conclusions. It is not necessary or even desirable, to repeat and quote at length from documents. What is most helpful is to let the facts speak for themselves, but add some interpretative information. In these days of electronic documents, it is not unreasonable to expect a contractor of substance to produce schedules to his claim, by way of Microsoft Excel or Project documents, and, using digital cameras, some photographs.

Excel is a very good way of showing events chronologically, and annotating them with a short comment. Types of delay can be listed on separate worksheets, with particular items highlighted in different colours. Text can be turned to a vertical orientation in column headings, and letters or numbers entered into cells to show what the Contractor is alleging. Project is a very telling and potent evidential programme. Remember that a picture paints a thousand words. Project has the advantage that it enables the Contractor to compile an as-built programme, and set it alongside the Clause 8.3 programme, showing delaying events. Links can be added, if they help.
Photographs are invaluable. If anyone's memory is cloudy, as it often is, a photograph dated and given a descriptive title, can provide the conclusive evidence.

The Engineer's Obligations

The Engineer is directed to respond with approval, or with disapproval and detailed comments, and in any event, respond on the principles of the claim. In making a determination of an extension, he must proceed in accordance with Clause 3.5. That requires him to consult with the Contractor, to try to reach agreement. If it is not possible to reach agreement, he must make a fair determination of the extension of time.

The Engineer is the first-step adjudicator or arbitrator. However, he is an informed adjudicator or arbitrator, unlike the tribunals who come on to the scene later on. The Engineer is not there to reject claims, but to deal with them fairly. That does not mean he has to allow unmeritorious claims. What it means is that, if the Contractor makes valid points, the Engineer should look into them, and arrive at a reasoned conclusion. Given that he is an informed adjudicator or arbitrator, the Engineer will have knowledge of the facts. This means he should not put the Contractor to proof of absolutely everything, in the way that a tribunal might expect.

Note also that, under Clause 8.4, the Engineer may make a number of determinations.

When doing so, he must review, and may revise, previous determinations. However, he may not decrease them.

1.2 Claims for payments

Procedures

The way in which such claims are to be dealt with is contained in Clause 20.1. The need for the Contractor to comply with the requirements of these provisions cannot be underestimated. Put bluntly, the Contractor is not entitled to payment if he does not comply with the procedural requirements. On the other hand, if there are genuine reasons why the times cannot be strictly observed, the Engineer should hear the Contractor's point of view. If the Employer is not prejudiced, it seems to matter little if something is a day or two late.

Notices and Supporting Particulars

The Contractor's obligations are set out in Clauses 20.1. Basically, he must start by giving notice of his intentions. Then, he must start putting together his particulars, and he must keep records.

Some people say if he fails to give a notice and particulars on time his claim fails. That is a harsh view, especially in regard to particulars, and is probably not sustainable in front of a lot of arbitrators. If the Employer does not suffer prejudice as a result of the lack of notice, and the Contractor is hardly late at all, it is hard to see why the claim should be rejected.
The real penalty for the Contractor is that, if the Engineer is not alerted to the Contractor’s intention to claim, or the Contractor’s claim is late, or it is not adequately substantiated, the Engineer may well not arrive at the sort of figure the Contractor is looking for. In fact, Clause 20.1 does anticipate that the Contractor may take some time to provide all of the information. It allows payment to him of claims, for which sufficient particulars have been provided.

The requirements for particulars for each head of claim are given under the relevant head below.

**Engineer’s Obligations in Regard to Claims**

The Engineer has to arrive at a decision on the claim. He cannot merely reject it, or deny it completely for want of one or two pieces of paper. On the other hand, he is not there to make the Contractor’s claim for him, or to certify payment due from the Employer in a carefree manner. It can be a hard balance to strike.

It may be helpful, when dealing with a contractor who is about to make a claim, to write and ask him for his particulars, or to keep records, using the Clause number and the exact terminology used in the Clause. In this way, he cannot accuse the Engineer of trying to obtain something the Engineer should not be asking for. It also means he cannot complain later that the Engineer had been unfair to him. If the Engineer receives a claim, he cannot put it on the shelf and leave it until the project has finished. The Engineer’s duty is owed to the Contractor as well as to the Employer. If the claim is paid later than it should have been, because the Engineer has kept it on the shelf for months, the Employer may be liable for financing charges. And he may sue the Engineer for them!

**Contractor’s Basic Entitlement**

The Contractor’s basic entitlement is summarised in Clause 12.1, which says that the Works shall be measured and valued. The onus is on the Engineer to do this.

**Variations**

Clause 13.3 sets out the procedure for variations. It is easy enough to follow. The valuation rules are contained in Clause 12.3. The onus is on the Engineer to measure and value variations, but, in reality, the Contractor may well wish to claim more than the Engineer’s valuation.

**Other Claims Clauses**

The genesis of claims lies in a number of Clauses throughout the Conditions, in addition to variations. A claim under the variations Clause is to have work valued.

Other claims, such as those listed under the time claims Clauses, which also allow money claims, are cost based. Some allow profit as well.

**Heads of Claim**

The heads of claim would normally be, as a maximum:
- Direct cost
- Indirect cost
- Overheads
- Financing Charges
- Profit
- Loss of Profit

Costs of preparing the claim, economic loss and consequential loss are generally not allowable, and nor is cost which is remote (see below).

**Recovery of Cost**

The first three of the items listed above are primary costs. Financing is a secondary cost, and is dealt with separately below. So, taking the direct and indirect costs and the overheads together, what is the criterion for recovery of cost? The usual rule is that applied in the leading case of *Hadley v. Baxendale* (1854).

The matters in respect of which claims for cost are made are breaches of contract. The inclusion in the Conditions of the claims Clauses provides the Engineer and the Contractor with the mechanism for agreeing damages, instead of the Contractor having to sue for them. The cost recoverable by the Contractor must therefore follow the common law damages rule. This relies on showing that the damage flows from the breach, or the cost flows from the event complained of.

This is causation. The Contractor must link cause and effect. He should not be required to provide as much evidence, especially oral evidence, as he would in arbitration, because the Engineer should be well acquainted with the facts. Nevertheless, the Engineer must ask himself if the cost flows from the event. There can be a temptation on the part of contractors to include all costs in their claims, without any apparent attempt to link cause and effect.

The measure of damage can be a difficult matter. The general rule is that damages should put the claiming party back into the position he would have been in, had the breach not taken place. That rule is given in the case of *Robinson v. Harman* (1848).

It is often helpful for the Engineer to ask himself, what would the Contractor have done, but for the breach?

Particulars of cost should not prove to be a problem. Direct costs are the site labour and plant. Any sensible contractor will have record sheets. They will show who and what was on site. What they probably will not show is (1) what the resources were doing and (2) why they were doing it. This will inevitably lead to some assessment being made.

Head office overheads can usually be proved by reference to pricing information behind the tender, or by using the Contractor’s audited accounts. If the accounts for years, other than those in which the Works were carried out, are used, care should be taken to ensure that the attribution of overheads to the proj-
ect is appropriate, and not inflated.

**Financing Charges**

Financing charges became a head of claim as a result of the case of *F G Minter v. Welsh Health Technical Services Organisation (1980)*. It established that there are two types of financing charge. One is the loss of interest on capital which the Contractor has not been paid, and been able to put into his bank account. The other type is the interest he incurs by way of overdraft in using his own money to finance work, whereas he would normally expect to use the money paid to him under the Contract.

Financing charges are a secondary cost. If his claim for costs fails, his claim for financing will fall with it. If the primary cost claim succeeds, it can be inferred that he has incurred financing charges.

There is not usually anything to be gained by looking at bank statements. They may show the Contractor had an overdraft, but that could be due to any reason, not necessarily connected with the matters claimed. In general, it is sensible to use a typical bank lending rate, plus 2%.

**Profit**

In certain instances, profit is allowed on Cost. The level of profit should be comparable to that in the Tender, which can be proved by reference to the Tender pricing information, and the Contractor should be prepared to produce it.

**Loss of Profit**

Loss of profit is usually the expression used to describe the damage suffered when the Contractor is kept on the project longer than anticipated, thereby losing the opportunity to earn profit on another project. It is difficult to establish, and will almost certainly suffer from being too remote.

**Global Claims**

Global claims achieved acceptance in the case of *Crosby & Sons Ltd v. Portland Urban District Council (1967)*. There is a string of cases on global claims. As a result, some people think that they have been outlawed. That is not true. However, the Contractor's first step must always be to try to particularize his claims in as much detail as possible. If it becomes impossible to do that, he may put forward his claim in a composite fashion, to the extent that it is unavoidable.

Obviously, care must be taken not to be overwhelmed with a weight of evidence and the blanket contention that, if there are so many variations, there must have been delay and disruption!

**Common Law Claims**

These are included in the claims made ‘otherwise’. There is nothing to stop the Contractor from making a claim for breach of either a contractual or tortuous duty. If the Engineer receives such a claim, he should treat it in the same way as any other claim. The grounds for making it should be clearly expressed and
there should be a link between cause and effect.

The circumstances in which a breach cannot be brought within any of the Clauses must be few. Framing a claim for breach can be difficult, and it may prove interesting to see how a contractor does it. (Papworth, J " Claims under the new Fidic condition of Contract ")

2 Types of disputes

Wong, T (2014) categorized the types of disputes as follows:

1.1 Owner related
- variations initiated by the owner
- change of scope
- late giving of possession
- acceleration
- unrealistic expectations
- payment delays

1.2 Contractor related
- delays in work progress
- time extensions
- financial failure of the contractor
- technical inadequacy of the contractor
- tendering
- quality of works

1.3 Design related
- design errors
- inadequate / incomplete specifications
- quality of design
- availability of information

1.4 Contract related
- ambiguities in contract documents
- different interpretations of the contract provisions
- risk allocation
- other contractual problems

1.5 Human behavior related
- adversarial/controversial culture
- lack of communication
- lack of team spirit

1.6 Project related
- site conditions
- unforeseen changes

1.6 External factors
- weather
- legal and economic factors
- fragmented structure of the sector

3 CAUSES OF DISPUTES

Azhar, S and Farooqui, 2014 summarized the causes for Disputes in the construction industry as follows:

3.1 Construction Relate Causes of Disputes

All of the planning, designing is translated into a physical entity through execution. And it is why the construction phase of a project is usually the most troublesome for project participants.

The problems are exaggerated more due to immensely differing practices among different project participants.

This section addresses the severity, frequency of those causes of disputes which are attributable to execution phase of a project.

3.2 Financial/Economical Causes of Disputes

Finance is one of the most important aspects of business management. In the context of construction business, “Project finance” refers to the financing of the project that is dependent on the project cash’s flows for repayment as defined by the contractual relationships within each project whereas the financial function plays a significant role in ensuring that company objectives are compatible with its resources.

For this reason the disputes have a monetary trait attached to it and it is of such magnitude which none
of the project participant is ever ready to absorb.

This section addresses the severity, frequency of those causes of disputes which are attributable to finance function of a project.

3.3 Management Related Causes of Disputes

Effective management of projects is becoming increasingly important for any type of organization to remain competitive in today’s dynamic business environment due to pressure of globalization.

Through application of construction management tools and techniques and observing a sound project management system, majority of the causes of disputes can be avoided thereby reducing the chances that any dispute arises in the first place and if such thing come about it does not escalate to such a level that it is converted into a major conflict or breach of contract.

In this section relevant causes of disputes attributable to the management function of a project are evaluated on the basis of severity, frequency of occurrence.

3.4 Contracts-Related Causes of Disputes

The business environment is full of agreements between businesses and individuals and construction is no exception. While oral agreements can be used is more appropriate to opt for formal written contracts when engaging in operations.

Written contracts provide individuals and businesses with a legal document stating the expectations of both parties and how negative situations will be resolved.

Contracts also are legally enforceable in a court of law. Contracts often represent a tool that companies use to safeguard their resources. If there are some flaws in the formulation of contract documents, ambiguous language of the contract can be a cause of dispute.

These causes and many others relevant to the domain of contract have a very high potential to be the source of diverse types disputes. In this section relevant causes of disputes attributable to the contract are evaluated on the basis of severity, frequency of occurrence. (Azhar,S,2014, Key causes of Disputes in Construction Industry’
According to the paper edited by Professor McGeorge, D, Dispute Avoidance and Resolution:

The below is the literature for some sources of disputes over the past years.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Source of Disputes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blake Dawson &amp; Waldron</td>
<td>2006</td>
<td>10 key issues in disputes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. variations to scope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. contract interpretation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. EOT claims</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Site conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Late, incomplete or substandard information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. NA/ or didn’t know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Obtaining approvals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. Site access</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Quality of design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. Availability of resources</td>
</tr>
<tr>
<td>Cheung and Yui</td>
<td>2006</td>
<td>Faulty Tree [fuzzy logic] model of root causes of disputes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[assumption that conflict is inevitable] 3 areas:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Conflict: Task interdependency, differentiations, communication obstacles, tensions, personality traits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Triggering events: Non performance, payment, time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Contract Provision</td>
</tr>
<tr>
<td>Yiu and Cheung</td>
<td>2004</td>
<td>33 dispute sources identified [literature] &amp; were ranked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 categories:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Construction related: 24 items</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Human behavior related: 9 items</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ranked from survey data and results:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Significant sources:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human behavior parties: expectations and inter parties’ problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>construction related: variation and delay in work progress</td>
</tr>
<tr>
<td>Kumaraswamy 61 projects in Hong Kong</td>
<td>1997</td>
<td>11 Time claim categories and 19 cost claim categories giving rise to two main groupings of causes of disputes and claims: root causes and proximate causes</td>
</tr>
</tbody>
</table>

Table 1 Literature and the sources of disputes

4 RESEARCH METHODOLOGIES

The general methodology of this study relies largely on the survey questionnaire responses which were collected from the Employer, the Engineer and the Contractor working on Fidic Contracts.

The questionnaire prepared for the survey was formulated by screening and comprehending the relevant literatures in the area of Construction Claims and Disputes. In order to aid the gathering of data
through primary source it was vital that a thorough literature review and past case studies were initially conducted to identify the various causes of disputes in the construction industry from an international perspective.

**Questionnaire Structure**

The Questionnaire was structured in 4 sections:

**Section A** – Interviewee's background but mostly targeting people with over 10 years experience.

**Section B** – Overview of the use of Fidic within the organization, just to get the feel of familiarity within that contract.

**Section C** - was on Contract Claims – The interviewee had to choose from a scale of 1 being strongly disagree to the scale of 5 being strongly agree. Different factors/influence were listed with are likely to cause claims.

**Section D** - was on Contract Disputes – The interviewee had to choose from a scale of 1 being strongly disagree to the scale of 5 being strongly agree. Different factors/influence were listed with are likely to disputes.

<table>
<thead>
<tr>
<th>Survey Response Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Questionnaires Distributed</td>
</tr>
<tr>
<td>Questionnaires Returned</td>
</tr>
<tr>
<td>Valid Responses</td>
</tr>
<tr>
<td>Percentage of Valid Responses</td>
</tr>
</tbody>
</table>

**Table 2 Survey Response Summary**

5 FINDINGS AND RESULTS

The data was analyzed by using content analysis. This included picking all the recurring statements and coding them in order to analyse and interpret the research data systematically and objectively.

Coding can be seen as the process of grouping evidence and labelling ideas so that they reflect increasingly broad perspectives (Creswell and Clark, 2007)

**Claim related factors/influence**
Table 3 Claims related factors/influence

<table>
<thead>
<tr>
<th>Contractors</th>
<th>Engineer</th>
<th>Employer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Conditions</td>
<td>Execution to work</td>
<td>Site Condition</td>
</tr>
<tr>
<td>Time Extension/Delays</td>
<td>Sub-contracting</td>
<td>Time Extension/Delay</td>
</tr>
<tr>
<td>Interruptions &amp; Disruptions</td>
<td>Payments and Adjustment of Contract</td>
<td>Payment and Adjustment of Contract</td>
</tr>
<tr>
<td>Change by Employer</td>
<td>Acceleration</td>
<td>Interruptions and Disruptions</td>
</tr>
<tr>
<td>Acceleration</td>
<td></td>
<td>Acceleration</td>
</tr>
</tbody>
</table>

Dispute related factors/influence

<table>
<thead>
<tr>
<th>Contractors</th>
<th>Engineer</th>
<th>Employer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of Conditions</td>
<td>Interpretation</td>
<td>Change of Conditions</td>
</tr>
<tr>
<td>Delay</td>
<td>Management</td>
<td>Delay</td>
</tr>
<tr>
<td>Change of Scope</td>
<td>Performance</td>
<td>Disruptions</td>
</tr>
<tr>
<td>Disruption</td>
<td>Disruptions</td>
<td>Payment and Adjustment of Contract</td>
</tr>
<tr>
<td></td>
<td>Payment</td>
<td>Contract Documents</td>
</tr>
<tr>
<td></td>
<td>Termination</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 Dispute related factors/influence

Even though there are many different factors with turn into claims and disputes these stood out to be the most common even between the Contractor, Engineer and the Employer.

Construction claims can be caused by a number of factors. Understanding what causes construction claims is the first step in avoiding them. In general, construction claims include but not limited to the below:

- Delays in construction and completion of the contract;
- Delays in the delivery and supply of materials;
- Weather which slows down or prevents construction from proceeding;
- Owner requested changes;
- Changes which occur not at the request of the owner;
- Poor management and administration of the construction site;
- Site conditions which differ from those expected;
• The work becomes impossible to perform;
• Insufficient plans and specifications;
• Failure of any one party to disclose information which is material to the construction;
• Conflicts between those involved in the construction of a project;
• Termination of the contract by the owner or the contractor;
• Acceleration of the work;
• Failure to adequately schedule and coordinate the work
• Failure of parties to cooperate with each other in the performance of the work.

6. CASE STUDIES

A case study of a Contractor who had various claims and disputes was analysed. The intent was to look at the things that have gone wrong to make the analysis of these claims difficult. And this report was prepared to serve as a lesson report in order to suggest the way forward for the Employer, The Engineer and Contractor from planning point of view.

Referring to Contract as a base document for project and utilizing the planning best practices as a guideline, a list of criteria has been developed which you can see in the table 5.
## Table 5: Planning and Control Status review

<table>
<thead>
<tr>
<th>Contract requirements and best practices</th>
<th>Status</th>
<th>Suggestion Made for future</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Schedule</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE-6 XER file and Printed copy</td>
<td>Done but not in all progress reports.</td>
<td>Double Check that both PDF and XER versions are included in monthly reports and all communications.</td>
</tr>
<tr>
<td>WBS</td>
<td>The WBS was developed and revised but there is no evidence that the Engineer has had any comment on it.</td>
<td>The Engineer needs to also check the WBS</td>
</tr>
<tr>
<td>Activity codes as per Engineer’s guideline</td>
<td>Activity codes are defined by Contractor for their internal structure and units.</td>
<td>Both Engineer and Contractor should agree on these activity codes.</td>
</tr>
<tr>
<td>Activity Units and quantities</td>
<td>It is included in some activities but the references and verification evidences is not available.</td>
<td>Use tender documents or any relevant accepted Standard as reference and complete the information.</td>
</tr>
<tr>
<td>Activity durations</td>
<td>Done but no evidence of validation and verification by client and/or engineer.</td>
<td>Validating the durations by team review</td>
</tr>
<tr>
<td>ES LS EF LF Dates (Early path and Late path)</td>
<td>It is traceable in the schedule but you can’t see them in the reports and the schedule view</td>
<td>These should be used to inform and lead the team with for float management</td>
</tr>
<tr>
<td>Milestones and key events</td>
<td>It is included in the schedule but the contractor suffers from lack of communication and information about external milestones.</td>
<td>Document the suggestions based on ongoing discussed scenarios and ask for confirmation by client</td>
</tr>
<tr>
<td>Critical Path</td>
<td>It is traceable in the schedule but there is no report on that.</td>
<td>Validating the critical path with contractor PM team, track and issue Critical path changes in every month reports</td>
</tr>
<tr>
<td>Activities duration longer than a month</td>
<td>According to Contract the activities over the 30 days should be broken down to proper duration and also according to planning best practice durations of the activities should be less than 2 week.</td>
<td>Break the activities longer than 2 week using the proper logic useful for progress measuring</td>
</tr>
<tr>
<td>Commissioning duration activities scale(day)</td>
<td>Scales are in day some of the activities has durations more than 1 day but it seems that there was no request from client to break down those activities.</td>
<td>If you are measuring the activities daily it is better to breakdown the activities to durations less than day</td>
</tr>
<tr>
<td>Cash flow an s-curves and quantities</td>
<td>It was not done , was not requested according to planner</td>
<td>In every monthly report overall S-curve and s curves for each unit and within each unit for each discipline should be prepared and presented.</td>
</tr>
<tr>
<td>Schedule assumption document</td>
<td>This was not in place</td>
<td>It needs to be developed and issued for signature for the valid baseline. And be updated onward.</td>
</tr>
</tbody>
</table>
7. RESULTS ANALYSIS

Based on the results of this research, the following conclusions can be drawn:

a) Delays in payment are the main important cause of claims because they result in a financial problem and disputes between the employer and the contractor.

b) Delays in work progress due to other factors are also the main factors according to all. These delays can be foreseen or unseen. They end up with claims for both extension of time and payment, if not sorted sooner can cause even further delays.

c) Disruptions and Interruptions – This is the worst cause of work delays, as it is not easy to avoid. In South Africa, striking, especially in large construction projects has become a norm.

d) Change of Scope - One of the major claim factors is that both employer and contractors do not put a good plan before starting a project. The employer usually does not know what he needs exactly. Also, contractors usually do not use any type of scheduling which may result in delay.

e) Performance: Other factor is that there is no control of the construction market, anyone could...
become a contractor. As a result, prices of contracts decrease, and therefore, the quality of work decreases.

f) Site Conditions – Change of site conditions is also one of the main factors in causing claims; these can also be foreseen or unforeseen. Most of the activities tend to change in a price schedule causing a lot of claims.

8. RECOMMENDATION FOR AVOIDING CONSTRUCTION CLAIMS AND DISPUTES

a) In the contract the rights and responsibilities of the contractors as well the rights and responsibilities of the employers and engineer should be clearly defined.

b) Give reasonable time to the design team to produce clear and complete drawings, bills of quantities, and specifications with no or minimum error and discrepancies.

c) Careful preparation of the contract documents helps to avoid disputes. Therefore, the documents will help to avoid disputes. Therefore the contractor should ask the owner to write the change orders instead of giving oral change orders.

d) Contractor should have signed change (variation) orders before starting doing any change in work on site.

e) Provide a proper mechanism for processing and evaluating change (variation) orders that pay for direct costs, indirect costs, and loss of productivity associated with any changes.

f) The contractor should take care of his work superiority by getting skilled labour and using good management techniques.

g) The government should create a set of procedures to control the quality of the construction work. Also, it should develop licensing contractors to make it more difficult to get certified.

h) The most excellent solution to claim lies in establishment of partnership between the owner and the contractor. Each party should try to solve the problems from the first moment they arise.

i) Use project software to make bar charts, critical paths, planning, scheduling, cost control, productivity analysis and most importantly the project progress report to control the delay of the project.

9 CONCLUSIONS

It is not easy to completely avoid however, the number of claims and subsequent disputes can be reduced if claims or disputes, there is a proper understanding and assessment of claims and better decision-making with regard to the claims process as a whole.
There is no guarantee that claims can be avoided entirely. Avoiding claims requires understanding their causes, understanding contractual terms and obligations, and early and continued effective non-adversarial communications. Claims should be resolved through reference to reduce liability. Contract terms should also be clearly interpreted.

It will also help them avoid the main causes of claims and disputes and, accordingly, minimize delays and cost overruns in construction projects.

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Cost analysis of building systems for single-family buildings in Cariri Ceará: conventional masonry and steel frame

ABSTRACT

Facing the rise of constructive methods such as Steel Frame conventional masonry has become increasingly less attractive. This is a consequence of the above-mentioned system advantages. However, in certain regions of Brazil the steel frame is still viewed with some concern, given that the common masonry has been the method most widely used for a long time and for much of the constructors. The purpose of this study is to evaluate which building system offers better cost-benefit relation in Southern Ceará, region called Cariri, through cost estimating comparison between Steel Frame and conventional masonry. The study was developed based on the analysis of a high standard single-family residence’s project, with total area of 230 m², estimating the same project for the two construction methods. The project data were given by an engineering office that operates in the region studied for over a year. From the architectural project, the foundations and the structures for conventional masonry system were calculated with the aid of AltoQi Eberick program. It can be seen that the overall cost of the project without indirect expenses using the conventional system was R$ 423,572.63, and using Steel Frame was R$ 554,462.87. The superstructure, walls, panels and coatings were the items that turned the use of steel frame unviable. On the other hand the roof and its protections were more expensive to conventional masonry system. It can be observed that the use of Steel Frame in Cariri has limitations such as the need for skilled labor and high wages for that unskilled labor. Because of the existence of only one company that works selling the steel profiles in the region, there is no competition; therefore there is no market price balance. It should be noted that the profiles used are manufactured in southern Brazil, adding to the product-shipping price. In conclusion, despite the Steel Frame has several advantages, the system was observed that conventional masonry system is still the most viable for single family building in Cariri.

Keywords: Steel frame, conventional masonry, economic viability, and construction cost-benefit.

1 INTRODUCTION

The construction industry in Brazil, still have little productive techniques and generate an exorbitant amount of waste. There is a certain difficulty in the incorporation of technological advances the production techniques, and this scenario often compounded by a lack of manpower training to absorb and make less craft these production techniques.

Most companies operating in the construction industry work with the conventional system using reinforced concrete to build the structure, but note that the companies have sought new building methods that can reduce the execution time of projects, rationalize the use of materials, improving quality of final product and reduce costs to remain competivas in an increasingly competitive market.
The conventional construction method is executed with brick ceramic blocks. The blocks are produced so predominantly artisanal from the burning of a clay mixture in kilns in potteries that are responsible for part of pollutant emissions, in addition to the express volume of wasted material throughout its production.

The concept of dry construction and the use of steel are one of the main alternatives aimed to change this construction scenario, especially the use of steel as Brazil is one of the largest producers of this material in the world. The use of such materials can make the most industrialized and streamlined processes. According to Santiago (2012), the use of steel in building construction has been significantly small compared to its industrial potential country.

A building system known worldwide for Light Steel Frame has been gaining ground in Brazil, mainly in the south and southeast. According to Rodrigues (2012), the steel frame is a self-supporting system that gathers both the dry building concepts such as the use of steel which aims to streamline the executive of the construction process and reduce material losses.

Before the emergence of constructive methods such as Steel Frame conventional masonry has become increasingly less attractive consequences arising out of the above-mentioned system advantages. However in certain regions of Brazil, the Steel Frame is still viewed with some concern, given that the common masonry has been the method most widely used for a long period and for much of the builders.

Note that this construction method began to be inserted in some construction companies in the region of Ceará Cariri. but it still presents difficulties not have many companies that work with the steel frame method, which apparently makes it less competitive in terms economic. Given this context came the interest in evaluating which Viability economic relationship gender mainstreaming by this innovative method over the method further used in Cariri which is the conventional masonry.

1.1 Objectives

Evaluate what building system presents the best costs through budget comparison between Steel Frame and conventional masonry ceramic block, using as a case study of a residential project of Ceará Cariri.

2 THEORETICAL FRAMEWORKS

2.1 MASONRY SYSTEM WITH CONVENTIONAL CERAMIC BLOCK

The construction method used in buildings in masonry is one of the oldest building systems, having a great acceptance by man in various civilizations. According Ximenes and Lima (2013), the masonry is the concomitant use of bricks or blocks joined together by a binder, mortar, resulting in the work in a firm and durable assembly.

According to NBR 8042 (ABNT, 1993), the main difference between bricks and blocks used in walls is that the bricks are solid ceramic elements and the blocks are ceramic elements that have holes generally prismatic orthogonal faces that contain it. There are several dimensions of ceramic blocks used in masonry
fence, but more used in the construction of walls of buildings is the block 9x14X19 cm.

The conventional masonry is generally used in combination with the structure made of reinforced concrete, forming a system already widely used in Brazil. According to Azeredo (1997), the construction system of conventional masonry in reinforced concrete are those composed of a structure of beams, columns and slabs of concrete cast in situ, sealed with built walls with ceramic blocks. This way of building has deficiencies as heavy weight, large amounts of waste, rework for electrical installation and hydro installation, too craft process and therefore very prone to errors ,, as plumb failures, level or square.

Reinforced concrete structures consist in the combination of two materials, concrete and steel, to work requests of different nature. Concrete works compressive stresses and steel works tensile stresses (and FERNANDES FILHO, 2010). In the conventional system masonry are designed to withstand loads beyond its own weight.

2.2 LIGHT STEEL FRAME SYSTEM

“The steel frame is a rational construction system consists of lightweight profiles galvanized steel, which form structural walls and non-structural after receiving the closure panels.” (TERNI; SANTIAGO, PIANHERI, 2008). The Steel frame is a lightweight self-supporting structure, so the foundation results in a simpler structure in most cases.

According to Santiago, 2012, the main benefits and advantages to using Light Steel Framing System (LSF) in buildings are:

- Because of the high technology used in the manufacture of products, their raw materials, characterization and standardization follow strict criteria of technological control;
- For high quality control and strength of steel, it allows a better performance of the structure and higher dimensional accuracy, and enabling a product to be repeatedly recycled without losing its properties;
- In areas where it is widely used by industry, there is the ease of obtaining the cold formed steel;
- The galvanizing process the profiles of manufacturing sheet provides durabilidade and longevity to the structure;
- The lightness of the elements creates ease of montage, handling and transportation;
- Construction method to dry that reduces the use of natural resources and waste;
- Elimination of rework in case of electrical and hydraulic installations, since the profiles drilled previously and the use of plasterboard panels facilitate implementation;
- As there is no need to manufacture the on-site elements, the site becomes a place only assembly, speeding up the construction process;
- Being mountable parts, do not limit the creativity of the architect, garantindo design flexibility.

However, the steel frame has a disadvantage. Its structure, to be self-supporting, has little flexibility
for repairs on site, therefore there should be no adjustments in the work and the foundation should not present repressal differential to be the correct transfer of the shares of the structure. For this motive, the foundation is the most commonly used is mat foundations/slab on grade, perfectly level and square.

3 MATERIALS AND METHODS

3.1 THE STUDIED AREA

The region of Cariri in which it was carried out this case study is located in the southern state of Ceará, Brazil. This region has a territorial extension of 152.256 million square kilometers, covering a total of twenty-seven municipalities with a population of 892,494 inhabitants, of which 70.15% are in urban areas (Ministry of Agrarian Development, 2016). On 26 June 2009 the Metropolitan Region Cariri was created from the SUPPLEMENTARY LAW No. 78. As the same constituted by the grouping of Juazeiro municipalities, Crato, Barbalha, Garden, Old Mission, Caririaçu, Farias Brito, New Olinda and Santana do Cariri. Its economic and cultural core revolves around the so-called triangle Crajubar (Crato, Juazeiro and Barbalha). According to the IBGE (Brazilian Institute of Geography and Statistics), GDP (Gross Domestic Product) of Ceara state in 2011 was R $ 84 billion, while the Cariri region was R $ 4.404 billion, representing a total of 4.76%. The region's economic growth has attracted the eyes of our investors, making new markets reach the region, especially the real estate market and by consequence the construction industry. In Figure 1 is shown a map of the metropolitan region of Cariri, with highlighting the municipalities that make up the Crajubar (Crato, Juazeiro and Barbalha).

Figure 1 - Região Metropolitana do Cariri
Fonte: QUEIROZ, 2014
3.2 ANALYSIS OF ECONOMIC FEASIBILITY

The study was conducted through the analysis of a project of a single-family residence, with total area of 230 m², luffing the same project for the two construction methods:

- reinforced concrete structure and sealing in conventional masonry with ceramic block;
- Light Steel Framing.

3.2.1. Characterization of the Building Project

The project data were awarded by engineering firm that operates in the region studied for over a year. The project consists of a residential duplex high standard. The land where the project will be executed is located in the municipality of Crato and has a total area of 450 m², from 35.05% occupancy rate, it has a 157,73 m² coverage area, natural soil rate 53.03% and decreases of 8.50m front, right 5.05m, 2.00m and 3.60m left background. The ground floor has parking for 01 car, with an area of 19.31 m², living room (13.87m²), dining room (20.22m²), kitchen (11.43m²), two bedrooms (10.52 and 8.84m²), two bathrooms (3.36 and 2.70m²), laundry area (9.33m²) and terrace (16.20m²), as ilustado in Appendix A. The upper floor has three suites. The suite double with a bedroom of 24m², one closet 6.37m², one bathroom and balcony 4.48m² 8.17m², the second suite with 12.20m², 4.48m² bathroom and a balcony 4.87m² and the third suite with a 14.50sqm bedroom and a bathroom 3.36m² as shown in Appendix B. the ground floor plus the higher totals an area to be built 238.03m².

The tool used in the preparation of the project was arquitetônico AutoCAD software. From the architectural with the aid of AltoQi Eberick program were developed projects of electric and hidrossanitárias facilities, foundations and reinforced concrete structure for conventional masonry system with ceramic block. All projects are designed following the requirements established by the technical standards in Brazil, this is the ABNT.

Considering the construction steel light framing, the project design process was to use the architectural design in a CAD frame application in order to obtain the appropriate modulation. In addition to the complementary projects, such as the electrical design and hidrosanitario was used Auto CAD always aiming at the compatibility of the projects, as for the implementation of a residence in steel frame requires that all projects talk and complete.

3.2.2. Budget spreadsheet

The cost estimate (budget) was prepared in accordance with budget techniques of identification, description, quantification and analysis of projects (architectural, structural and facilities).

The services were described as projective services in engineering (development projects), primary services, earthwork, infrastructure, superstructure, walls and panels, cover and protection, frames and hardware, coatings, paints, flooring, hydraulic systems, electrical systems and complementary services.

As a research source of compositions and pricing of conventional services (foundations, reinforced con-
crete structure, walls and panels, coatings, etc.) was used Table 023 Secretariat of Ceará Infrastructure (SEINFRA-CE). For the pricing of construction services in Steel Frame (superstructure, walls and panels and roof structure) was used to quantify developed by a provider of steel cold formed sections and plates providers (OSB, cement, drywall, etc.) the Cariri Region from architectural design and structural pre-project in Steel Frame. A summary of budget spreadsheets conventional system and steel frame, respectively, in appendix C and D.

4 RESULTS AND DISCUSSIONS

According to the comparative spreadsheet of costs of services applied in the design and construction of residential duplex unit (Table 1) you can see that the projective services in engineering (item 1), preliminaries services (item 2), ground handling (item 3) below true (item 4), window frames and fittings (item 8), painting (item 10), flooring (item 11), hidrossanitárias facilities (item 12), electrical installations (item 13) and complementary services (item 14), did not show variation in relation to the systems evaluated.

Already superstructure services (item 5), walls and panels (item 6), cover (item 7), coating (item 10) and paint (item 12), showed significant variation between the systems adopted. Note that if these services are the items that determine whether the system has cost feasibility or not.

In the Super-Structure service (item 5) observed a difference of R$ 88,344.84 between actual costs of the systems, and the system in Steel Frame presented the highest total cost around R$ 140,605.24 reais. The same behavior was observed in item 6 (walls and panels) and item 9 (coating). However, the service walls and panels cost for the system in concrete structural Armed and conventional Masonry in ceramic block was R$ 23,386.09 real, and the system in Steel Frame was R$ 54,958.90 reais, representing a difference of cost of R$ 31,572.81 reais between systems in this item. In the coating service notes a difference of R$ 20,540.86 between actual costs of the systems, and the system in Steel Frame presented the highest cost around R$ 140,605.24 reais.

Among the items that showed variation of cost, coverage and protection service (item 7) was the one who presented the opposite behavior in relation to other services because the system in concrete structural Armed and conventional Masonry in ceramic block system had cost R$ 21,218.31 with a real difference around R$ 9,568.28 less for the system in Steel Frame.

Finally, it can be seen that the overall cost of the project without overhead subsidies using the system in concrete structural Armed and conventional Masonry in ceramic block was R$ 423,572.63 reais and Steel Frame was R$ 554,462.87 real.

The comparative spreadsheet of the costs of the systems indicates a difference of significant overall cost of construction of the building system Steel frame in relation to the construction system of structural concrete and masonry conventional ceramic block, with the traditional system considerably more economically viable. Unlike the system in Steel frame in relation to the concrete structural Armed and conventional Masonry in ceramic block is approximately R$ 130,890.24 real, this is equivalent in percentage 31% of the total cost of building concrete structural Armed and conventional Masonry in ceramic block and 24% of the total cost of construction in Steel Frame.
Although the schedule of a work presents directly proportional relation to the cost, it is worth mentioning that this research is based on only the budget analysis, i.e., not taking into account the schedule (time) of the construction work. According to Chemin, Philip, and Goulart (2013), reports that the steel frame method using industrialized profiles (prefabricated) it is possible to rationalize the work of time, especially the team regards the manufacture of the structure, because it allows multiple steps to be performed simultaneously and in different places.

<table>
<thead>
<tr>
<th>Item</th>
<th>Step</th>
<th>Project</th>
<th>System Concrete structural Armed and conventional Masonry in ceramic block</th>
<th>System Steel Frame</th>
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<td>1</td>
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<td>R$ 6.760,05</td>
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<td>R$ 9.039,80</td>
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<tr>
<td>3</td>
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<td>R$ 47.610,77</td>
<td>R$ 47.610,77</td>
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<tr>
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<td>Infrastructure</td>
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<td>R$ 63.850,77</td>
<td>R$ 63.850,77</td>
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<tr>
<td>5</td>
<td>Superstructure</td>
<td></td>
<td>R$ 52.260,40</td>
<td>R$ 140.605,24</td>
</tr>
<tr>
<td>6</td>
<td>Walls and panels</td>
<td></td>
<td>R$ 23.386,09</td>
<td>R$ 54.958,90</td>
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<tr>
<td>7</td>
<td>Coverage and Protection</td>
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<td>R$ 21.218,31</td>
<td>R$ 11.650,03</td>
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<td>R$ 28.470,05</td>
<td>R$ 28.470,05</td>
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<td>9</td>
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<td>Hydro installations</td>
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<td>Electrical Installations</td>
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<td>Complementary services</td>
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<td>R$ 1.609,08</td>
<td>R$ 1.609,08</td>
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<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>R$ 423.572,63</strong></td>
<td><strong>R$ 554.462,87</strong></td>
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</table>

It can be seen that the use of Steel Frame in the Cariri has limitations as qualified labour, the little hand of existing skilled labour in the region is more runtime compared to hand labour specialized areas where the steel frame system is more popularized, thereby undermining one of the main characteristics of this system is the speed of execution.

As regards the system Steel frame have shown a much higher cost compared to the traditional system in the case of buildings in Cariri is related to the fact there is only one company that works with the sale of profiles in the region, with no competition so therefore no market price balance. It should be noted that the profiles used are manufactured in southern Brazil, adding to the product-shipping price.

Only in 2008 it was founded the only company in Drywall market Cariri. Juazeiro was chosen as the venue to be a strategic point, because although it is the smallest municipality, with 248km², jujube is the most populous and the largest economy in the region, thus representing a regional metropolis, plus it is close to a gypsum mine and recently has had an economic growth that exceeds expectations. Thus there was a growing interest in new technologies in the design of buildings that could ease the structures and increase production speed. From this, some enterprises began to use the drywall as a constructive system,
replacing the conventional masonry block by plasterboard already well known around the world.

However, insecurity printing and fragility of this new type of masonry made builders slow to convince users to trust the drywall. This cultural issue was considered at first an obstacle to overcome. However, currently they can already be found several enterprises that use such technology.

Based on the achievement of the plasterboard market entry began in the steel frame business, construction method structured in galvanized steel cold formed steel, designed to withstand the loads of the building and working together with other sub-systems industrial (ECKER and MARTINS, 2014). One more step in lean construction, since today seeks to achieve more sustainable work technically, economically, socially and environmentally; generating less waste, using less raw material, reducing rework and qualifying workers. Already exists in the region, focused courses to manpower training to work with this construction method.

In the study developed by Hass and Martins (2011), evaluating the economic viability of the use of steel frame system in the construction of social housing in the city of Curitiba in comparison with the conventional masonry system, obtained considerably competitive results economically with a difference between only R $ 1,000.00 real systems, with Steel Frame costs the highest. These results stand out even more influence over the profiles price of freight on the high cost of the system Steel frame in Cariri.

**5 FINAL CONSIDERATIONS**

The cost analysis for the two systems evaluated in this study showed that for the construction of residential buildings single-family conventional method showed the lowest cost, proving to be significantly more economically viable compared to new technologies such as the method using the steel system frame.

Could observer that the factor that make the system more expensive steel frame is the distance from Cariri over the region whose profiles are manufactured in the south of the country. Adiconando the product freight costs, for example.

As this work constitutes only an analysis of the systems costs is suggested as future work to practical systems analysis, assessing the gains deadlines and reducing waste at the construction site (dry construction). Another factor that is important to be examined is the performance of local labor in relation to these construction technologies as the steel frame.

**6 REFERENCES**


HASS, D. C. G. MARTINS, L. F. *Viabilidade econômica do uso do sistema construtivo steel frame como mét-


TERNI, ; SANTIAGO, ; PIANHERI,. Steel frame - fundações. Téchne, São Paulo, n. 135, Junho 2008.

APPENDIX A - Floor plan of the ground floor
APPENDIX B - Upper Floor
# APPENDIX B - Upper Floor

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Code</th>
<th>Unit</th>
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<td>4.11</td>
<td>Launch and implementation of concrete s / lift</td>
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<td>CA-50A armor average D = 6.3 to 10.0mm</td>
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<td>Concrete p / vibr., FCK = 25MPa produced with aggregate (S / TRANSP.)</td>
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<td>Prefabricated slab w / Floor- go up to 4,01 m</td>
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<td>Launch and concrete application w / lift</td>
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<td>9.1</td>
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<td>Grouting C / ARG. PREFABRICATED, JUNTA Between 2mm and 6mm CERAMIC, UP 30x30 cm (900 cm²) and porcelain tiles (WALL / FLOOR)</td>
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<td>GYPSUM CONVENTIONAL LINER (60x60) cm WITHOUT SHOOTING AND WIRE GALVANIZED jacketed - SUPPLY AND ASSEMBLY</td>
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<td>CONCRETE BALLAST INCLUDING PREPARATION AND RELEASE</td>
<td>5.62</td>
<td>M3</td>
</tr>
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<td>11.2</td>
<td>C2181</td>
<td>BASIC ADJUSTMENT C / MORTAR CEMENT AND SAND S / Sifting, TRACE 1: 3 - ESP = 3cm</td>
<td>199.11</td>
<td>M2</td>
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<td>11.3</td>
<td>C4440</td>
<td>PORCELAIN POLISHED C / ARG. CEMENT AND SAND P / FLOOR</td>
<td>199.11</td>
<td>M2</td>
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<td>11.4</td>
<td>C1427</td>
<td>Grouting C / ARG. PREFABRICATED, JUNTA Between 2mm and 6mm CERAMIC, UP 30x30 cm (900 cm²) and porcelain tiles (WALL / FLOOR)</td>
<td>199.11</td>
<td>M2</td>
</tr>
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<td>C4066</td>
<td>GRANITE POLISHED E = 2cm, WHITE, MORTAR CEMENT AND SAND 1: 4, C / grouting</td>
<td>5.90</td>
<td>M2</td>
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<td>C4001</td>
<td>FOOTING GRANITE H = 10 cm</td>
<td>123.05</td>
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<td>11.7</td>
<td>C2284</td>
<td>BOTTOM OF GRANITE L = 15cm</td>
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<td>C1869</td>
<td>SILL GRANITE L = 15 cm</td>
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<td>Mutirão JOINT - CONCRETE FLOOR DEAD OF FCK = 13.5 MPa C / PREPARATION AND RELEASE</td>
<td>2.43</td>
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<td>C3446</td>
<td>STEPPING interlocked TYPE flagstones (19,9x10x4) cm GRAY</td>
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<td>12</td>
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<td>FACILITIES HIDROSSANITÁRIAS</td>
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<td>12.1</td>
<td>C2594</td>
<td>PVC PIPE WHITE P / SEWER D = 100mm (4&quot;) - JUNTA C / RINGS</td>
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<td>C3994</td>
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<td>C2347</td>
<td>HAVE PVC WHITE C / REDUCTION P / D = SEWER 100X50mm (4&quot; X 2&quot;)</td>
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<td>C0609</td>
<td>CASH IN MASONRY (60X60X60cm) 1/2 OF COMMON BRICK, CONCRETE BALLAST AND CONCRETE COVER</td>
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<td>C0601</td>
<td>GREASE BOX / SOAP IN MASONRY</td>
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<td>C2271</td>
<td>SIPHON CHROME 1 &quot; x 1 1/2&quot; (INSTALLED)</td>
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<td>C0348</td>
<td>WHITE DISHES BOWL C / CASH ATTACHED</td>
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<td>C0357</td>
<td>GRANITE COUNTER (OTHER COLORS) E = 3cm (LAY)</td>
<td>2.50</td>
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<td>C0986</td>
<td>DISHES OF CUBA BUILT C / COCK AND ACCESSORIES</td>
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<td>C0797</td>
<td>SHOWER PLASTIC (INSTALLED)</td>
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<td>C0796</td>
<td>SHOWER ELECTRIC AUTO-2800 220V / 4400W (INSTALLED)</td>
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<td>C2505</td>
<td>PRESSURE TAP CHROME GENERAL USE</td>
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<td>C3682</td>
<td>TANK LAUNDRY STAINLESS STEEL C / CUBA AND SCRUBBER DIMENSION 1200X600X200MM</td>
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<td><strong>HYDRAULIC INSTALLATION</strong></td>
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<td>C2618</td>
<td>HOSE PVC SOLD. BROWN D = 40mm (1 1/4&quot;)</td>
<td>18,32</td>
<td>M</td>
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<td>C2617</td>
<td>HOSE PVC SOLD. BROWN D = 32mm (1&quot;)</td>
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<td>C2616</td>
<td>HOSE PVC SOLD. BROWN D = 25mm (3/4&quot;)</td>
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<td>C2169</td>
<td>LOG DRAWER C / canopy CHROME D = 40mm (1 1/2&quot;)</td>
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<td>LOG DRAWER C / canopy CHROME D = 32mm (1 1/4&quot;)</td>
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<td>REGISTRATION OF PRESSURE C / canopy CHROME D = 25MM (1&quot;)</td>
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<td>C2497</td>
<td>COCK BUOY D = 20mm (3/4&quot;)</td>
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<td>C1562</td>
<td>KNEE REDUCTION PVC SOLD. BLUE D = 25mmX1 / 2 &quot;</td>
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<td>C2381</td>
<td>HAVE SOLD PVC. BROWN D = 25mm (3/4&quot;)</td>
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<td>C2379</td>
<td>HAVE PVC SOLD./ROSCA BLUE D = 25mmX25mmX3 / 4 &quot;</td>
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<td>12,31</td>
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<td>C2399</td>
<td>HAVE REDUCED PVC ROSC. D = 1 &quot;X 3/4&quot; (32X25mm)</td>
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<td>C1563</td>
<td>KNEE REDUCTION PVC SOLD. BLUE D = 32mmX3 / 4 &quot;</td>
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<td>C0953</td>
<td>ELBOW PVC SOLD. BROWN D = 25mm (3/4&quot;)</td>
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<td>C0955</td>
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<td>C1566</td>
<td>KNEE REDUCTION PVC SOLD.MARROM D = 40X32mm (1 1/4 &quot;X 1&quot;)</td>
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<td>C2383</td>
<td>HAVE SOLD PVC. BROWN D = 40mm (1 1/4&quot;)</td>
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<td>C3442</td>
<td>Water tank IN FIBERGLASS - CAP. 1000L</td>
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<td>C1242</td>
<td>HITCH PLASTIC (INSTALLED)</td>
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<td>C0022</td>
<td>ADAPTER PVC SOLD. FLANGES FREE P / CX. WATER 40mm (1 1/4&quot;)</td>
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<td>ADAPTER PVC SOLD. FLANGES FREE P / CX. WATER 60mm (2&quot;)</td>
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<td>PRESSURE COCK P / GARDEN 3/4&quot;</td>
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<td>SWITCH TWO KEYS SIMPLE 10A 250V</td>
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<td>13.18</td>
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<td>13.21</td>
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<td>13.26</td>
<td>C2067</td>
<td>LIGHT DISTRIBUTION TABLE BUILT UP TO 12 DIVISIONS 207X332X95mm, C / BUS</td>
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<td>13.27</td>
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<td>CASH IN MASONRY (60X60X60cm) 1/2 OF COMMON BRICK, GRAVEL AND CONCRETE BALLAST OF COVER</td>
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<td>13.28</td>
<td>C0517</td>
<td>COPPER CABLE 10mm2 NU</td>
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<td>13.29</td>
<td>C2009</td>
<td>POLE IRON P / GARDEN H = 2.80m, C / LAMP GLOBE AND SODIUM VAPOR 70W</td>
<td>1,00</td>
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<td>13.30</td>
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<td>GROUND COMPLETE C / RODS copperweld P / STOP-RAYS</td>
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<td>TABLE OF MEASUREMENT STANDARD COELCE - STANDARD POPULAR</td>
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**13** ELECTRICAL INSTALLATION **R$ 19,542,70**

**14** ADDITIONAL SERVICES **R$ 1,609,08**
## 14.1 GENERAL CLEANING

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**TOTAL:** 12,34

**BDI:** 21.00%

**TOTAL:** 15,08

---

### APPENDIX B - Upper Floor

#### 1 SERVICES projective ENGINEERING

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<th>Code</th>
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**TOTAL:** 202,65

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#### 2 PRELIMINARY SERVICES

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<td>C2102</td>
<td>SCRAPING AND LAND CLEANING</td>
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<td>C2851</td>
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<td>C2849</td>
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**TOTAL:** 2.500,00

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#### 3 GROUND MOVEMENT

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<td>C2784</td>
<td>EXCAVATION MANUAL 1A.CAT SOIL. PROF. UP TO 1.50m</td>
<td>M3</td>
<td>25,59</td>
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<td>C1268</td>
<td>EXCAVATION MECAN. OPEN FIELD ON EARTH EXCEPT TO ROCK 4M</td>
<td>M3</td>
<td>2,45</td>
<td>688,25</td>
<td>1,644,00</td>
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<td>C0328</td>
<td>LANDFILL C / COMPRESSION MECHANICS AND CONTROL, MAT. ACQUISITION</td>
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<td>C0330</td>
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#### 4 INFRASTRUCTURE

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<td>C0055</td>
<td>Basement MASONRY COMMON BRICK, C / MORTAR MIXED C / HYDRATED LIME</td>
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<td>C1400</td>
<td>BOARDS OF FORM 1 &quot;OF 3A. P / UTIL FOUNDATIONS. 5 X</td>
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<td>C0216</td>
<td>ARMOR CA-50A MEAN D = 6.3 The 10.0mm</td>
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<td>302,52</td>
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<td>C3273</td>
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**TOTAL:** 1.309,17

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#### 5 SUPERSTRUCTURE

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<td>CXXX</td>
<td>KIT STEEL FRAME</td>
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**TOTAL:** 121.802,55

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**TOTAL:** 121.802,55
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<td>MIXED SLAB (OSB + subfloor)</td>
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<td>WALLS AND PANELS</td>
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<td>COVERAGE AND PROTECTION</td>
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<td>7.1</td>
<td>CERAMIC TILE THE COWL CHANNEL &quot;Timon&quot;</td>
<td>5.45 M</td>
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<td>7.2</td>
<td>DRUM / ALGEIROZ CONCRETE PRECAST L = 30CM</td>
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<td>BORDER AND TILE IN COLONIAL BICA</td>
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<td>CERAMIC TILE</td>
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<td>7.5</td>
<td>WATERPROOFING C / EMULSION ASPHALT CONSUMPTION 2 kg / m²</td>
<td>217.61 M2</td>
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<td>161.57 M2</td>
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<td>FRAMES AND BRACKETS</td>
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<td>PROTECTIVE ALUMINUM GRADE</td>
<td>19.78 M2</td>
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<td>8.2</td>
<td>TYPE IRON WINDOW FRAME DUMP OR FIXED</td>
<td>0.40 M2</td>
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<td>WINDOW IN ANODIZED ALUMINIUM NATURAL / MATT, SLIDING WITH pennant AND / OR SILL WITHOUT GLASS - SUPPLY AND ASSEMBLY</td>
<td>14.85 M2</td>
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<td>3,954.56</td>
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<td>8.4</td>
<td>GLASS TEMPERED IN FRAME C / ESP MASS. = 6mm</td>
<td>29.13 M2</td>
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<td>DOOR IN ALUMINIUM ANODIZED NATURAL / MATT, SLIDING WITHOUT pennant AND / OR SILL WITHOUT GLASS - SUPPLY AND ASSEMBLY</td>
<td>14.28 M2</td>
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<td>4,049.81</td>
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<td>9</td>
<td>JACKETS</td>
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<td>EXTERNAL FINISH - PLATES cementitious</td>
<td>550.08 M²</td>
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<td>PORCELAIN POLISHED C / ARG. CEMENT AND SAND P / WALL</td>
<td>151.26 M2</td>
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<td>9.5</td>
<td>Grouting C / ARG. PREFABRICATED, JUNTA Between 2mm and 6mm CERAMIC, UP 30x30 cm (900 cm³) and porcelain tiles (WALL / FLOOR)</td>
<td>151.26 M2</td>
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<td>848.57</td>
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<td>9.6</td>
<td>GYPSUM CONVENTIONAL LINER (60x60) cm WITHOUT SHOOTING AND WIRE GALVANIZED jacketed - SUPPLY AND ASSEMBLY</td>
<td>199.11 M2</td>
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<td>10</td>
<td>PAINTINGS</td>
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<td>10.1</td>
<td>OUTSIDE WALLS EMASSAMENTO 2 COATS C / MASS ACRYLIC</td>
<td>264.07 M2</td>
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<td>LATEX TWO COATS ON WALLS INTERNAL S / MASS</td>
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<td>GLAZE TWO COATS TIMBER FRAMES</td>
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### BASIC ADJUSTMENT C / MORTAR CEMENT AND SAND S / Sifting, TRACE 1: 3 - ESP = 3cm

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<td>C2181</td>
<td>Porcelain Polished / Arg. Cement and Sand P / Floor</td>
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<td>C1427</td>
<td>Grouting C / Arg. Prefabricated, Junta Between 2mm and 6mm Ceramic, UP 30x30 cm (900 cm²) and porcelain tiles (Wall / Floor)</td>
<td>199.11</td>
<td>5.61</td>
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<td>C4066</td>
<td>Granite Polished E = 2cm, White, Mortar Cement and Sand 1: 4, C / Grouting</td>
<td>5.90</td>
<td>354.78</td>
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<td>C4001</td>
<td>Footing Granite H = 10 cm</td>
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<td>C2284</td>
<td>Bottom of Granite L = 15 cm</td>
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<td>C1427</td>
<td>Mutirão Joint - Concrete Floor Dead of FCK = 13.5 MPa C / Preparation and Release</td>
<td>2.43</td>
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### FACILITIES HIDROSSANITÁRIAS

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<td>PVC Pipe White P / Sewer D = 100mm (4”) - Junta C / Rings</td>
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<td>C2595</td>
<td>PVC Pipe White P / Sewer D = 40mm (1 1/2”)</td>
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<td>PVC Pipe White P / Sewer D = 50mm (2”)</td>
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<td>C1754</td>
<td>Sleeve Plain White PVC P / Sewer D = 100mm (4”) - C / Rings</td>
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<td>C1756</td>
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<td>C1760</td>
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<td>C4388</td>
<td>Knee 45 PVC White For Sewage D = 40mm (1 1/4”)</td>
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<td>C4669</td>
<td>Knee 45 PVC White For Sewage D = 50mm (2”)</td>
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<td>C4378</td>
<td>Cash In siphoned PVC 185 x 150 x 75 mm C / Chrome Grille</td>
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<td>C2093</td>
<td>Ralo Seco PVC Rigid</td>
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<td>C0609</td>
<td>Cash In Masonry (60X60X60cm) 1/2 of Common Brick, Concrete Ballast and Concrete Cover</td>
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<td>C0601</td>
<td>Grease Box / Soap in Masonry</td>
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<td>C2271</td>
<td>Siphon Chrome 1 ”X 1 1/2” (Installed)</td>
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### TABLEWARE AND METALS

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<td>White Dishes Bowl C / Cash Attached</td>
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<td>C0357</td>
<td>Granite Counter (Other Colors) E = 3cm (Lay)</td>
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<td>C0986</td>
<td>Dishes of Cuba Built C / Cock and Accessories</td>
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<td>C0797</td>
<td>Shower Plastic (Installed)</td>
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<td>SHOWER ELECTRIC AUTO-2800 220V / 4400W (INSTALLED)</td>
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<td>C2505</td>
<td>PRESSURE TAP CHROME GENERAL USE</td>
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<td>C3862</td>
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<td><strong>HYDRAULIC INSTALLATION</strong></td>
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<td>C2618</td>
<td>HOSE PVC SOLD. BROWN D = 40mm (1 1/4 *)</td>
<td>18.32</td>
<td>M</td>
</tr>
<tr>
<td>C2617</td>
<td>HOSE PVC SOLD. BROWN D = 32mm (1 1/4 *)</td>
<td>9.12</td>
<td>M</td>
</tr>
<tr>
<td>C2616</td>
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<td>83,00</td>
<td>M</td>
</tr>
<tr>
<td>C2169</td>
<td>LOG DRAWER C / canopy CHROME D = 40mm (1 1/2 *)</td>
<td>1.00</td>
<td>UN</td>
</tr>
<tr>
<td>C2168</td>
<td>LOG DRAWER C / canopy CHROME D = 32mm (1 1/4 *)</td>
<td>3.00</td>
<td>UN</td>
</tr>
<tr>
<td>C2167</td>
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<td>UN</td>
</tr>
<tr>
<td>C2170</td>
<td>REGISTRATION OF PRESSURE C / canopy CHROME D = 25MM (1 *)</td>
<td>5.00</td>
<td>UN</td>
</tr>
<tr>
<td>C2497</td>
<td>COCK BUOY D = 20mm (3/4 *)</td>
<td>1.00</td>
<td>UN</td>
</tr>
<tr>
<td>C1562</td>
<td>KNEE REDUCTION PVC SOLD. BLUE D = 25mmX1 / 2 &quot;</td>
<td>13,00</td>
<td>UN</td>
</tr>
<tr>
<td>C2381</td>
<td>HAVE SOLD PVC. BROWN D = 25mm (3/4 *)</td>
<td>10,00</td>
<td>UN</td>
</tr>
<tr>
<td>C2379</td>
<td>HAVE PVC SOLD./ROSCA BLUE D = 25mmX25mmX3 / 4 &quot;</td>
<td>8,00</td>
<td>UN</td>
</tr>
<tr>
<td>C2399</td>
<td>HAVE REDUCED PVC ROSC. D = 1 &quot;X3/4&quot; (3X25mm)</td>
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</tr>
<tr>
<td>C1563</td>
<td>KNEE REDUCTION PVC SOLD. BLUE D = 32mmX3 / 4 &quot;</td>
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</tr>
<tr>
<td>C0953</td>
<td>ELBOW PVC SOLD. BROWN D = 25mm (3/4 *)</td>
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<tr>
<td>C0955</td>
<td>ELBOW PVC SOLD. BROWN D = 40mm (1 1/4 *)</td>
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<tr>
<td>C1566</td>
<td>KNEE REDUCTION PVC SOLD.MARROM D = 40X32mm (1 1/4 &quot;X 1&quot;)</td>
<td>3.00</td>
<td>UN</td>
</tr>
<tr>
<td>C2383</td>
<td>HAVE SOLD PVC. BROWN D = 40mm (1 1/4 *)</td>
<td>2.00</td>
<td>UN</td>
</tr>
<tr>
<td>C3442</td>
<td>Water tank IN FIBERGLASS - CAP. 1000L</td>
<td>3.00</td>
<td>UN</td>
</tr>
<tr>
<td>C1242</td>
<td>HITCH PLASTIC (INSTALLED)</td>
<td>11,00</td>
<td>UN</td>
</tr>
<tr>
<td>C0022</td>
<td>ADAPTER PVC SOLD. FLANGES FREE / CX. WATER 40mm (1 1/4 *)</td>
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</tr>
<tr>
<td>C0024</td>
<td>ADAPTER PVC SOLD. FLANGES FREE / CX. WATER 60mm (2 *)</td>
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</tr>
<tr>
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<td>UN</td>
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<tr>
<td>C2506</td>
<td>PRESSURE COCK P / GARDEN 3/4 *</td>
<td>1.00</td>
<td>UN</td>
</tr>
<tr>
<td></td>
<td><strong>ELECTRICAL INSTALLATION</strong></td>
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</tr>
<tr>
<td>C1196</td>
<td>CONDUIT PVC ROSC.INCL.CONEXÕES D = 25mm (3/4 *)</td>
<td>503,50</td>
<td>M</td>
</tr>
<tr>
<td>C1197</td>
<td>CONDUIT PVC ROSC.INCL.CONEXÕES D = 32mm (1 *)</td>
<td>26,17</td>
<td>M</td>
</tr>
<tr>
<td>C1374</td>
<td>ISOLATED WIRE PVC P / 750V 2.5 MM2</td>
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<td>M</td>
</tr>
<tr>
<td>C1375</td>
<td>WIRE ISOLATED PVC P / 750V 4mm2</td>
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<td>M</td>
</tr>
<tr>
<td>C1376</td>
<td>ISOLATED WIRE PVC P / 750V 6mm2</td>
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<tr>
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<tr>
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<td>UN</td>
</tr>
<tr>
<td>C1637</td>
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<td>UN</td>
</tr>
<tr>
<td>C1494</td>
<td>SWITCH A BUTTON PLAIN 10A 250V</td>
<td>11,00</td>
<td>UN</td>
</tr>
<tr>
<td>C1479</td>
<td>SWITCH TWO KEYS SIMPLE 10A 250V</td>
<td>2.00</td>
<td>UN</td>
</tr>
<tr>
<td>Código</td>
<td>Descrição</td>
<td>Unidades</td>
<td>Preço</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>13.12</td>
<td>C1492 SWITCH A BUTTON PARALLEL 10A 250V</td>
<td>11,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.13</td>
<td>C1489 SWITCH THREE KEYS SIMPLE 10A 250V</td>
<td>1,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.14</td>
<td>C1483 SWITCH TWO KEYS SIMPLE AND OUTLET 10A 250V</td>
<td>3,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.15</td>
<td>C1496 SWITCH A BUTTON SIMPLE AND UNIVERSAL PLUG 10A 250V</td>
<td>3,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.16</td>
<td>C2483 COMPLETE P / COMPUTER OUTLET</td>
<td>4,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.17</td>
<td>C2486 OUTLET P / PHONE 4 POLES STANDARD TELEBRAS</td>
<td>2,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.18</td>
<td>C2484 TAKE 2 POLES MORE LAND 20A 250V</td>
<td>38,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.19</td>
<td>C2494 OUTLET VOLTAMP - 30A (MALE / FEMALE)</td>
<td>8,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.20</td>
<td>CXXX OUTLET FOR TV</td>
<td>6,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.21</td>
<td>C1092 BREAKER MONOPOLAR IN DISTRIBUTION TABLE 10A</td>
<td>5,00</td>
<td>UN</td>
</tr>
<tr>
<td>13.22</td>
<td>C1093 BREAKER MONOPOLAR IN DISTRIBUTION TABLE 16A</td>
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<td>13.23</td>
<td>C1096 BREAKER MONOPOLAR IN DISTRIBUTION TABLE 25A</td>
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<td>UN</td>
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<tr>
<td>13.24</td>
<td>C1111 BREAKER TRIPOLAR C / DRIVES IN PORT Q.D.ATE 32A</td>
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<td>UN</td>
</tr>
<tr>
<td>13.25</td>
<td>C2077 LIGHT DISTRIBUTION TABLE BUILT UP TO 6 DIVISIONS, C / BUS</td>
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<td>UN</td>
</tr>
<tr>
<td>13.26</td>
<td>C2067 LIGHT DISTRIBUTION TABLE BUILT UP TO 12 DIVISIONS 207X332X95mm, C / BUS</td>
<td>1,00</td>
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<tr>
<td>13.27</td>
<td>C0632 masonry box (60X60X80cm) 1/2 common brick, gravel ballast and concrete cover</td>
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<td>UN</td>
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<tr>
<td>13.28</td>
<td>C0517 COPPER CABLE 10mm2 NU</td>
<td>6,80</td>
<td>M</td>
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<tr>
<td>13.29</td>
<td>C2009 POLE IRON P / GARDEN H = 2.80m, C / LAMP GLOBE AND SODIUM VAPOR 70W</td>
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<tr>
<td>13.30</td>
<td>C0327 GROUND COMPLETE C / RODS copperweld P / STOP-RAYS</td>
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<tr>
<td>13.31</td>
<td>C3579 TABLE OF MEASUREMENT STANDARD COELCE - STANDARD POPULAR</td>
<td>1,00</td>
<td>UN</td>
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<td></td>
<td>ADDITIONAL SERVICES</td>
<td></td>
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<tr>
<td>14.1</td>
<td>C1628 GENERAL CLEANING</td>
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TOTAL: 554.462,87

BDI: 20,00%

TOTAL: 665.355,45
Contingencies for an Enterprise

Günter Banda Schulz-Nöthling

ABSTRACT

This paper deals with the concepts and proposes definitions and scope limits to be utilized in the calculation of the “Contingencies” for a project from the point of view of the owner of an enterprise. The terms, provisions, risks and opportunities and the term contingencies itself for an investment estimate are often utilized in an imprecise and generic manner, with broad and conflicting interpretations, which results in disastrous consequences for innumerable enterprises when inadequate provisions are made.

It can be said that there is a diversity of educational backgrounds or technical knowledge among those who will make decisions regarding the proposed value of an investment with a given “contingency”. Consequently, erroneous interpretations of the applicability of the provision adopted for a project may result in decisions based on poorly clarified and defined information. It is known that, generally speaking, with investment estimates there is a strong tendency to extrapolate the initially estimated values. A critical and independent analysis over the life of a project can not only forecast future unfavorable events, but can also result, through lessons learned, in improvements to the calculations for estimates for new projects. An effort is therefore being made here to propose a new transparent system to be used for estimates with the main focus being the identification, in an organized manner, of the variables affected and their respective potential values. It should also be remembered that estimation demands experience and defending an estimate is not an easy task in all of the spheres.

Keywords: contingency, investment estimate, risks and opportunities.

1 OBJECTIVE

With many investment estimates developed from the point of view of the enterprising party, the term “Contingencies” is broad and normally utilized in a generic manner without going into great detail. This is due to the broad coverage and scope. Professionals from various disciplines have different perceptions of the content, concept and applicability. Consequently, investors may make poor or erroneous decisions after being led to believe that all the related possible uncertainties are covered or protected by one item in an investment estimate called, simply, “Contingencies”, which may in fact be merely a provision for a small portion that is being covered.
The purpose here is to propose a system or methodology for the calculation of a portion of an investment estimate, frequently allocated as a simple line called “contingencies”, but which, in percentage terms, will be one of the most important, and perhaps the biggest, items for the project. The goal is also to orient and provide greater transparency and traceability for the premises assumed over the life of a project, aiming not only at the identification or forecasting of future problems, but also, through lessons learned, at the provision of support to projects to come.

2 ANTECEDENTS

The goal here is to attempt to identify the most appropriate manner of dealing with the “Contingencies” theme within an investment estimate, gathering together not only currently recognized techniques and methodologies, but also adding experience acquired in over 50 projects worked on in the mining field in the past 20 years, in all their various phases.

The past 20 years have seen a sharp increase in the number of mining projects being developed and implemented. The figures involved have also jumped from the range of millions dollars to the level of billions of dollars. An example of this would be an iron ore project in Brazil that, 20 years ago, was estimated at approximately USD 12.00/t. This same project is today estimated at USD 120.00/t produced, with this figure being highly variable not only in function of the quality of the Run of Mine, but also in function of the innumerable other variables, such as the long period required for development and implementation, the available infrastructure, compliance with legal and environmental legislation and regulations and others.

For a very large number of projects, the values that are to be invested and that were initially forecast are extrapolated. This makes it imperative that this theme be given special treatment during the analysis phase, as experience demonstrates that an inadequate provision may lead to disastrous consequences for the investor.

Based on the information presented in specialized publications, it can be seen that there are innumerable definitions for the term “contingencies”. There are situations where the theme is mixed together with provisions for risk mitigation, provisions to prevent impacts on the schedule, amounts reserved for unexpected work, amounts dedicated to preventing possible variations in the estimated quantities and prices and others. Consequently, there is an urgent need to establish and define rules for the application of a clearer concept, right from the moment at which an investment estimate is prepared.

The intention here is thus to propose a hierarchy for the amounts involved in this theme that may be allocated within an investment estimate in a manner that facilitates understanding by the reader or decision-maker.

3 THE COMPOSITION OF AN INVESTMENT ESTIMATE

The example that will be used here is an investment estimate composed of a bidimensional matrix, with the first matrix composed of the activities that will be undertaken for the enterprise (equipment, materials and services) and the second composed of the physical areas of the enterprise. The first dimension
can be further classified into two large themes, as shown below:

- **Direct Investments**: these, generally speaking, represent roughly 100% of the work performed directly by the engineering and architecture disciplines. This item should also include what are known as Design Allowances, which are items that, while known to be necessary, have not yet been sufficiently detailed by the engineering discipline, though experience with projects already undertaken demonstrates they will be necessary or will occur.

- **Indirect Investments**: these cover all the other items not related to the previous item and that contemplate the remaining scope of the enterprise. Of note among these investments are: commissioning, owner’s team, general implementation expenses, environmental licensing, environmental compensation, spare parts, taxes, freight, engineering and management. Also of note are the “contingencies” item itself, risks and opportunities, escalation and the management reserve.

This classification is not strict and may be adjusted to fit each type of project, though experience demonstrates the importance of seeking to separate items of a more technical nature that are linked directly to engineering/architecture from the other factors. Secondary classifications may also be useful, especially when there is significant external infrastructure in comparison with the internal project structures, in which case these values must be dealt with independently with the goal of obtaining more correlatable metrics.

The second dimension of the matrix, related to a physical area or asset of the project, called the WBS or Work Breakdown System, must also be created, even for simpler projects or projects that are in their initial phases. It is important to note that the items from one dimension must not be mixed with those from the other and they should always be dealt with independently, as this greatly facilitates the creation of metrics based on similar comparatives. Special attention should also be paid to the strictness of the control of the WBS for the project, from the very first stages, since a badly conceived WBS will have negative effects on the entire network of actions that depend on it, including implications for future budget control. Though this may seem to be an obvious and elementary observation, errors of this nature are constantly found in a wide variety of projects.

Regardless of how detailed the engineering work is, especially the items related to direct investments, there are no guarantees that the estimate will not exceed the estimated limits; the degree of variability in the estimated value can be limited, though it is rare to arrive at the final value initially used as a reference. In addition, indirect investments always represent a significant portion when compare with the direct investments and can easily exceed 40% of the value for the direct investments, depending on the scope that has been defined for this item.
Figure 1 illustrates the first dimension of the matrix discussed here, along with its main components.

FIGURE 1 – Direct and Indirect Investments

4 PROPOSED CONCEPTS

Based on the vast amount of literature available on the subject, much of which is conflicting, along with the experience acquired over the years, the following concepts are being proposed, in a brief manner, for what is being dealt with here as "Contingencies". These concepts should be observed when preparing an investment estimate. Note that concepts such as risk and opportunities have also been added with
the goal of ensuring that they are not confused with or unduly allocated to the items that we are calling “contingencies”.

Bernstein contributed significantly to what is sought to be characterized here as “contingencies” and “risks” when he said that there is “a persistent tension between those who affirm that the best decisions are based on quantification and on numbers, which are determined based on past patterns, and those that base their decisions on more subjective degrees of belief regarding an uncertain future. This controversy will never be resolved.”

4.1 Project Contingencies

Contingencies may thus be characterized in the following manner:

- Contingencies are an integral part of the investments and should not be considered separately;
- They are an amount destined to cover undefined items or cost elements that will be incurred within the scope of the project, as has been shown to be the case with previous projects;
- They are a provision that is not directly correlated with the accuracy of the estimate and, thus, should not be considered as compensation for imprecision in the estimate. It is important to mention that the use of risk analysis tools, such as Monte Carlo simulations, for accuracy estimates, does not imply that risks are covered by the analysis performed. This reinforces the need to clarify which variables were dealt with in the variability analysis performed in order to separate them from other later analyses, thus avoiding duplicity in the consideration of the effects of given approaches or the failure to consider other probable or possible variations.
- They may not be estimated under the effects of uncertainties or indeterminable cost elements;
- They are entirely predictable and will be spent in their entirety;
- They cover possible alterations in the prices of materials, equipment and services, project changes (except changes in scope), errors, omissions, schedule slippages and possible variations in labor productivity.
- They should not incorporate amounts for items such as take-off allowances and equipment growth allowances, design development allowances, etc. These amounts, when applicable and necessary, must be allocated within the direct investments;
- They are not intended to cover any costs resulting from potential changes in scope, force majeure, currency fluctuations or escalation;
- They do not cover the management reserve or risks of any nature, which should be dealt with separately in their own item;
They do not totally eliminate the possibility of a project overrun, but rather are aimed at minimizing the related effects within determined acceptable levels.

### 4.2 Risks and Opportunities

For the purposes of investment estimates, it can be understood that risk:

- is an event “above or beyond” normal conditions;
- should have one or more triggers with a reasonable cause;
- should have a probability of occurrence of between 1% and 99%;
- will have an impact on key elements defined for the project, such as quality, costs, the schedule or safety, among others.
- is an event that, if it occurs, may require additional measures that were not included in other management tools.

Risk should not be viewed as a challenge that must be dealt with by the project team and should also not be interpreted as a checklist to be followed or complied with. It is also not an item that is to be mitigated through the use of other management tools, such as the schedule, budget or control over changes in scope, among others.

On the other hand, Opportunities are understood to be circumstances that are favorable to the entering party and that may be identified during both the design and implementation phases. Opportunities act in a contrary manner to that defined for risks.

The methodology for the calculation of risks and opportunities involves an analysis of the factors that may affect the project based on the relative probability of occurrence, consequences and manageability. Next, their effects before and after mitigation actions have been taken are estimated. The most common approaches are related to situations resulting from external elements not directly related to the project, risks of a technical nature or those that appear in function of the degree of innovative technology adopted in the industrial process, the qualifications of the suppliers contracted and of the team that will work under the management of the owner, among others. Under no circumstances should these items be superimposed over the effects of the contingencies analysis being suggested here, or that is to say, they should be dealt with independently.

It is important to highlight that the opportunities identified, even those with a high probability of occurrence, should not be integrated into the estimate as an accepted fact as is commonly done in advance by optimists. In these cases, it is recommended that they be treated in a transparent manner and separately from the other items with the goal of marking them clearly throughout the decisionmaking processes. They should always be based on the premises and circumstances that led to their adoption, thus avoiding their assumption at inappropriate or inadequate moments. Experience demonstrates that this item is used as a matter of routine by more optimistic estimators and that this can compromise the entire budget execution for the enterprise in the future.
5 THE CONTINGENCY ESTIMATION PROCESS

The process of estimating the contingencies for a project begins with the establishment of its coverage and applicability in a precise manner, thus avoiding interpretations that are divergent from the true purpose. Next is the establishment of the pillars upon which the contingencies and their possible variations will be assessed, in quantitative and qualitative terms as relate to the investment estimate involved. With this done, it is expected that it will be possible to estimate the ranges of variation in the estimate or its accuracy within the pre-established parameters or pillars.

The quantitative analysis of the items forecast for an investment estimate may be dealt with and analyzed in accordance with the following aspects:

- Intensification of the engineering effort applied so far, in comparison with that necessary to conclude the project;
- Possibility of being associated with any project errors or omissions;
- Susceptibility to changes or updates to the project prior to implementation (excluding changes in scope);
- Qualification of the topographical survey and of geological-geotechnical investigations that support the quantitative surveys;
- Methodology for the calculations for the dimensioning of the planned structures;
- Degree of definition of the scope.

In qualitative terms there are the following points:

- The level of detail of the information provided to the supplier for quotations of equipment and materials;
- The manner in which prices are obtained: whether prices are firm proposals or are merely for reference or budget purposes;
- The reliability and level of detail of the information received from the suppliers consulted;
- Potential variation in labor costs and productivity rates;
- Potential variation in prices for materials and equipment, supported in part by references from the data bank.
Based on the quantitative and qualitative analyses mentioned, percentage variation range groups are created. For each of these groups, subgroups with three scale levels are established:

- **Lower Range** – with a higher percentage amplitude, indicating that the item analyzed has a reference base that is similar, but not specific to the item analyzed.

- **Medium Range** – with an intermediate percentage amplitude, lying between the other levels, and composed of references that are appropriate and well-correlated, though not specific.

- **Upper Range** – with a lower percentage amplitude, indicating that the sources that are well supported are well-correlated or are specific to the object of the analysis.

For each item listed in the investment estimate or groups of items, a quantitative percentage variation range will be established. Next, the susceptibility to qualitative variations will be established. The combination of the two parcels, multiplied by the respective estimated values, will provide the average and extreme amounts to which the estimate will be subject. Table 1 illustrates the reference matrix for the variation ranges for each of the groups and subgroups established. For each item in the estimate a minimum and maximum quantitative percentage will be established within each subgroup; the same will be done for the qualitative assessment.

**Table 1 – Groups and Subgroups for the Quantitative and Qualitative Analyses**

<table>
<thead>
<tr>
<th>Quantitative Analysis / Qualitative Analysis</th>
<th>Subgroup 1</th>
<th>Subgroup 2</th>
<th>Subgroup 3</th>
</tr>
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<tbody>
<tr>
<td>Low Limit</td>
<td>Medium Limit</td>
<td>Upper limite</td>
<td></td>
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<tr>
<td>Quantitative Analysis</td>
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<td></td>
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</tr>
<tr>
<td>Group 10</td>
<td>-X₁% / +X₃%</td>
<td>-X₄% / +X₆%</td>
<td>-X₇% / +X₉%</td>
</tr>
<tr>
<td>Group 11</td>
<td>-X₄% / +X₆%</td>
<td>-X₉% / +X₁₀%</td>
<td>-X₁₁% / +X₁₃%</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Group M</td>
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<td>...</td>
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<tr>
<td>Qualitative Analysis</td>
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<tr>
<td>Group 20</td>
<td>-Y₁% / +Y₃%</td>
<td>-Y₄% / +Y₆%</td>
<td>-Y₇% / +Y₉%</td>
</tr>
<tr>
<td>Group 21</td>
<td>-Y₄% / +Y₆%</td>
<td>-Y₉% / +Y₁₀%</td>
<td>-Y₁₁% / +Y₁₃%</td>
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<td></td>
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</tr>
<tr>
<td>Group N</td>
<td>...</td>
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</tr>
</tbody>
</table>
As an example, if it has been defined that item “i” falls within group 10 and subgroup 3 in quantitative terms and that the same item falls within group 21 and subgroup 1 in qualitative terms, the extreme limits will be defined in the following manner:

Extreme below variation $Ai$: $(1+X5\%)*(1+Y1\%)$
Extreme above variation $Bi$: $(1+X6\%)*(1+Y2\%)$
Average: $(Ai + Bi)/2$

When the extreme and average limits for all the items listed in the estimate have been constructed as shown and with the utilization of tools such as @Risk, it is possible to obtain the most likely probability distribution curve for the most likely values for an investment estimate, within a given confidence interval, which will lend support to the contingency values to be recommended.

It should be noted that, within the range of variation to which the estimate is subject and its accuracy, possible future variations in scope and risk elements of any nature are not included. In summary, it can be said that the accuracy depends on the quality of the information available at the time the estimate is prepared, on the cost base adopted, on the methodology utilized for the preparation of the estimate and on the experience and judgement of the estimator.

Note that an effort is made to avoid the presentation of the percentages normally applied or observed in projects for each group established, in view of the fact that there is a wide range of factors that may affect them, even under given specific and common conditions. The variability to be established does not depend solely on deterministic factors, which are easier to estimate. The determination of this variability also depends heavily on the task group that generated the information that is supporting the investment estimate for the project and, above all, on the previous work and experience of the group involved in the preparation of the estimate.

6 IMPLICATIONS OF A PRACTICAL NATURE

Listed below are situations of a practical nature that have been observed over the years and that may affect the reliability of an investment estimate or that may indicate that a project should be looked at in greater detail, with regard to specific aspects. These situations may also contribute towards minimizing the values that should be provisioned for in an estimate:

- A highly detailed quantitative assessment, provided by the engineering discipline working on the project, does not guarantee that the final value will experience greater variations than expected. The experience of the estimator is not limited solely to what has be recorded, but rather must go beyond that which can be seen.

- Underestimated indirect investments, especially those that are independent of the engineering work performed, may represent a significant parcel of the project and deserve special attention when being estimated;
The investment estimate must be constituted in an independent manner. Stakeholders, generally speaking, may fail to mention factors that may contribute to the infeasibility of a project, which deserves, in this case, adequate corrections. An appropriate revision of the scope is better than improperly based linear cuts through given items of the enterprise.

There is no standardized universal methodology for the estimation of the contingencies for a project; care must be taken when assuming fixed percentages using different bases than those established for the project. The figure to be adopted, or the adoption of a comfortable percentage, does not guarantee its accuracy.

The investment estimate process does not finish with the end of the project phase. The process must be continued during the implementation phase, preferably by the same professionals, since continuity of knowledge may not only be a contributing factor to the current project, but may also serve to support future projects;

Continuity in the estimate process and in budget control, from the beginning of the project through to the most critical moments, should be viewed as a constructive and contributive tool that will aid in achieving success for the project and should never be interpreted as an impediment to the finalization of the project;

Budget control during the implementation process, based on pre-established premises, is an extremely useful tool for managers and should not be given a secondary level of importance. It is common to see managers that are concerned with delivering a given project within the budget, but that while attempting to do so compromise the scope or transfer non-executed parcels to the contingencies item, which was not prepared with such impacts in mind;

Estimates, even those that are well-founded and that do not reach the project feasibility expectation, are subject to pressure to reduce given parameters that, in principle, should not be altered. The contingencies item is one of the items that is most often questioned, especially with regard to its importance to the project, which is why it should not simply be estimated as a mere percentage point;

The effort made, the dedication of the team and the time available for the preparation of the investment estimate are also crucial to the reliability and seriousness of the process;

The utilization of an independent auditor for investment estimates, including the possible use of competing consulting companies, may be an extremely useful tool for the identification of possible weak points in a project. Projects undertaken with a high degree of participation by stakeholders, independent of their level of competence, may completely compromise the feasibility of the enterprise when this results in a failure to introduce into the estimate recommendations based on lessons learned from other projects.

Integration among the supply, estimation, budget control and upper management areas of the project, without limitations, by means of strong reliability links between them, may serve as an excellent path towards the correct disbursement of the provisions made for the project.
The report on the premises adopted (Basis of Estimate – BoE) in the investment estimate is a fundamental component of the analysis of investment estimate deviations, for all of the related versions or revisions, including the preliminary versions, as this report assists with the validation of any alterations made. Executive summaries tend not to show all the interfaces, premises, corrections and their consequences, as they generally deal only with the most optimistic themes.

7 CONCLUSIONS

There is no established universal methodology for estimating the total amount of provisions that should be made for a given project, let alone a single consensus regarding the concepts to be applied. However, it is of fundamental importance that there be a clear definition of the concepts and scope applied for Contingencies and Risks & Opportunities, including the clear definition of the items for which no provisions have been made, when applicable.

Integration between the various management areas of a project and the creation of reliability links between these areas and, especially, those areas that are involved with monetary values (supplies, estimation, budget control and the upper management of the project) is a factor that is of fundamental importance to the success of the enterprise. Work undertaken without barriers results in significant gains for all those involved.

The methodology proposed here contributes towards a more accessible level of transparency for all parties involved and can also be employed in combination with other methodologies that deserve attention.

A well-structured investment estimate that is detailed and contains explanations of the concepts is key to the minimization of the extrapolation of the figures estimated and will lend strong support to decisionmakers. Lessons learned from past projects must constructively contribute towards subsequent projects and must not be seen as harmful or punitive to the knowledge.

8 REFERENCES

In the formation of a cost structure and pricing of an item, the factors involved are detailed and obey the following structure:

**A. MATERIALS**

This first component has its importance in the cost structure, where, magnitude and amount depend on the definition or technical specifications and characteristics of each of the materials that make up the item characteristics.

An important factor that should be considered to define the performance of inputs, is the experience of the technicians and engineers of the company, it is reflected in the work methodology and application of appropriate technologies for the specific project.

The following diagram allows us to objectively interpret these concepts:
B. WORKFORCE

This component presents a dichotomy in its application, the first execution time of the work unit, expressed in performance, it difficult to determine factor, the same that is linked to the experience of the engineers of the company, the methodology work and the most important part, education of workers in the construction field.

The second corresponds to pay wages to the workers running the item, which must be calculated considering all issues under existing laws demand in our country.

B.1 Social Charges

It is the determination of the percentage of the wage or basic salary. In order that the granting of subsidies for the family allowance scheme, does not collide with interpretive problems, it has consulted the respective agencies application, must take into account the company (employer) compliance with the provisions contained in Article 25 DS 21637 of 25/06/87, Art. The 2nd of S.D. 23410 of 16/02/93, 29/11/96 Act 1732, S.D. No. 24586 of 29/04/97, S.D. No. 24646 of 6/12/97.

B.1.1 Incidence of inactivity

The incidence of inactivity, may vary according to the type of work; as for the construction of roads or bridges, you have more days without recovery loss due to bad weather, which for architectural works such as urban and rural buildings, including multifamily housing developments or plans.

The following table shows the days that make up the calendar year with their respective days of idle, considering that according to D. S. No. 21060 Art. 67 of Chapter III, points out that there are 12 public holidays in the country, including departmental ephemeris.
B1.2 Incidence of Subsidies

As of January 1, 1993, pursuant to the provisions contained in section 2 of DS No. 23410 of 16 February 1993 amending the amount of the national minimum wage, prenatal allowances, birth, lactation and burial, whose duty is paid by the company to or employers, as provided by Supreme Decree No. 21637 in its article 25 of June 25, 1987, they should be considered within the cost structure. It also deserves explanation of the importance of each of the subsidies cited.

B.1.2.1 Prenatal allowance.- Is delivering the insured beneficiary (a) a monthly allowance in whole milk, cheese, yogurt, cereal and iodized salt, equivalent to a national salary during the five (5) months of pregnancy, regardless of incapacity benefit temporary.

B.1.2.2 Birth allowance.- Is the delivery through the insured, to the mother, or beneficiary mother, a single payment equivalent to one (1) national minimum wage, for the birth of each child.
B.1.2.3 The Nursing allowance.- It consists of the monthly delivery of whole milk, and other equivalent to one (1) products national minimum wage for each child during the first twelve (12) months.

B.1.2.4 Burial allowance.- Payment consists of one (1) national minimum wage for the death of each child under 19 years. Failure by the company, in the granting of any of the four grants shall be punished in accordance with the provisions contained in paragraph n) of Article 592 and 593 of the regulations of the Social Security Code, as follows:

(A) For the first time, a sum equal to twice the subsidy paid.

(B) In case of recidivism, with the urgency of the executive of the employing entity, to the fulfillment of the obligation, but the fine.

(C) In the case of continuous reception was enacted, with the intervention or closure of the company.

Being boxes health, responsible for control systems, as well as applying sanctions. For control purposes, companies or employers are required to split the payroll payroll employees and beneficiaries who are entitled to family allowances.

In case of violation of this law, employers are required without prejudice to the corresponding penalties, to continue granting all family benefits for periods established, even if the worker had been taken illegally.

A summary table of subsidies expressed in bolivianos shown:

national minimum wage = 1,805.00 Bs.
Number of workers = 60
Number of months / year = 12

<table>
<thead>
<tr>
<th>SUBSIDIES</th>
<th>AMOUNT</th>
<th>PERIOD IN MONTHS</th>
<th>TOTAL TO CANCEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prenatal</td>
<td>1,805.00</td>
<td>5</td>
<td>9,025.00</td>
</tr>
<tr>
<td>Birthrate</td>
<td>1,805.00</td>
<td>1</td>
<td>1,805.00</td>
</tr>
<tr>
<td>Lactancy</td>
<td>1,805.00</td>
<td>12</td>
<td>21,660.00</td>
</tr>
<tr>
<td>Burial</td>
<td>1,805.00</td>
<td>1</td>
<td>1,805.00</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td></td>
<td><strong>19</strong></td>
<td><strong>34,295.00</strong></td>
</tr>
</tbody>
</table>

For the analysis of the impact of subsidies it is necessary to determine the average monthly cost of labor, for this purpose we determine the wages or average monthly salary weighted, based on current market prices and the weighted prices established in DS 18948 of 4/17/82.
It is also necessary to determine the number of workers for a project, considering 60 workers of which 10% represents former workers, with these data we determined the percentage of the incidence of subsidies.

### WEIGHTED AVERAGE SALARY

<table>
<thead>
<tr>
<th>OCCUPATION</th>
<th>SALARY</th>
<th>D. S 18948 Pro. PonderED (%)</th>
<th>Salary Pond. Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pawn</td>
<td>100.00</td>
<td>40</td>
<td>1,200.00</td>
</tr>
<tr>
<td>Assistán</td>
<td>110.00</td>
<td>25</td>
<td>825.00</td>
</tr>
<tr>
<td>Builder 2da.</td>
<td>180.00</td>
<td>20</td>
<td>1,080.00</td>
</tr>
<tr>
<td>Builder 1ra.</td>
<td>190.00</td>
<td>10</td>
<td>570.00</td>
</tr>
<tr>
<td>Especialist</td>
<td>210.00</td>
<td>5</td>
<td>315.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100</td>
<td>3,990.00</td>
</tr>
</tbody>
</table>

**Weighted Average Salary = 3,990.00 Bs.**

Data that the incidence of subsidy is calculated:

Average Monthly Salary = 3,990.00 Bs.
Number of workers = 60
Number of months/year = 12
total-salary/year = time*N° builders*SPM

Total wages s/year = 2,872,800.00 Bs. / Year

Therefore, the incidence of subsidies be:

\[ i = \frac{139,292.0 \text{ Bs} \times 100\%}{2,872,800.0 \text{ Bs}} \]

SUBSIDIES = 4.67%

B.1.3 Contributions incidence of entities.- Current legal issues governing employer contributions are as follows and whose value is discounted by the payroll to workers and employees:

<table>
<thead>
<tr>
<th>CONTRIBUTIONS TO ENTITIES</th>
<th>PATRONAL</th>
<th>LABOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Health Fund</td>
<td>10.00 %</td>
<td>--------</td>
</tr>
<tr>
<td>Occupational hazards</td>
<td>2.00 %</td>
<td>--------</td>
</tr>
<tr>
<td>AFP Capitalization</td>
<td>--------</td>
<td>10.00 %</td>
</tr>
<tr>
<td>Housing fund</td>
<td>2.00 %</td>
<td>1.00 %</td>
</tr>
<tr>
<td>Infocal</td>
<td>1.00 %</td>
<td>--------</td>
</tr>
<tr>
<td>Comisión AFP’s</td>
<td>--------</td>
<td>0.50 %</td>
</tr>
<tr>
<td>Solidarity contribution</td>
<td>--------</td>
<td>0.50 %</td>
</tr>
<tr>
<td>Common risk</td>
<td>--------</td>
<td>2.00 %</td>
</tr>
<tr>
<td><strong>TOTAL CONTRIBUTIONS</strong></td>
<td><strong>15.00 %</strong></td>
<td><strong>14.00 %</strong></td>
</tr>
</tbody>
</table>

CONTRIBUTIONS TO ENTITIES = 15.00 %

B.1.4 Calculating the impact of antiquity.- According to the provisions of Decree Law No. 21060, it is considered the age of two to four years, equivalent to 5% of the national minimum wage.

For this calculation it was considered that only 10.00% of the 60 workers are old, the incidence is calculated as follows:

\[ x = \frac{5.0\%}{10.00\%} \]
B.1.5 Calculating the impact of industrial safety and hygiene.- the following items for the safety of the workers are considered basic, and this more limited non-restrictive list.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>CANTIDAD</th>
<th>QUANTITY</th>
<th>CALCULATIONS</th>
<th>TOTAL Bs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellingtons</td>
<td>25</td>
<td>110.00</td>
<td>Cant. * Price / N workers</td>
<td>45.83</td>
</tr>
<tr>
<td>Leather Glove</td>
<td>180</td>
<td>25.00</td>
<td>Cant. * Price / N workers</td>
<td>75.00</td>
</tr>
<tr>
<td>Plastic glove</td>
<td>60</td>
<td>15.00</td>
<td>Cant. * Price / N workers</td>
<td>15.00</td>
</tr>
<tr>
<td>Workwear</td>
<td>60</td>
<td>165.00</td>
<td>Cant. * Price / N workers</td>
<td>165.00</td>
</tr>
<tr>
<td>Helmets</td>
<td>60</td>
<td>110.00</td>
<td>Cant. * Price / N workers</td>
<td>110.00</td>
</tr>
<tr>
<td>Security belt</td>
<td>12</td>
<td>75.00</td>
<td>Cant. * Price / N workers</td>
<td>15.00</td>
</tr>
<tr>
<td>Goggles</td>
<td>18</td>
<td>135.00</td>
<td>Cant. * Price / N workers</td>
<td>40.50</td>
</tr>
<tr>
<td>First aid kit</td>
<td>2</td>
<td>1080.00</td>
<td>Cant. * Price / N workers</td>
<td>36.00</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>502.33</strong></td>
</tr>
</tbody>
</table>

And the average monthly incidence:
(502.33.00 Bs Laborer / year) / (12months / year) = 41.86 Bs. Worker / month

Making the transformation percentage are:
((41.86 Bs. Worker / month) * 100%) / (3,990.00 Bs. Worker / month)

**INDUSTRIAL SAFETY AND HEALTH = 1.05 %**

**SUMMARY OF INCIDENTS OF SOCIAL SECURITY TAXES**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>INCIDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>INACTIVITY</td>
<td>47.90 %</td>
</tr>
<tr>
<td>SUBSIDIES</td>
<td>4.67 %</td>
</tr>
<tr>
<td>CONTRIBUTIONS TO ENTITIES</td>
<td>15.00 %</td>
</tr>
<tr>
<td>ANTIQUITY</td>
<td>0.50 %</td>
</tr>
<tr>
<td>SEGURIDAD INDUS.</td>
<td>1.05 %</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>69.13 %</strong></td>
</tr>
</tbody>
</table>

**SOCIAL CHARGES = 69.13%**
C. TOOLS AND EQUIPMENT

To determine the costs of machinery, equipment and lower tools accurately be considered separately yields schedules of machinery and equipment used in each item, where the percentage of machinery and equipment is calculated, as well as minor tools they used in a play.

For the calculation of machinery and equipment in construction, must be determined for each machine or equipment the following:

- The Performance Schedule
- Cost Schedule

Most manufacturers of machinery and equipment have calculated the corresponding yields to each machine. The hourly cost is a result of operating costs and investment. The list of small tools may be minimal to run architectural works or buildings, with only limited, but not limited to, having the engineer, who performs cost engineering list all the tools to be used in the specific project.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>UNITY</th>
<th>QUANTITY</th>
<th>PRICE (Bs.)</th>
<th>DURATION (years)</th>
<th>TOTAL COST (Bs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counterbalance</td>
<td>Pza</td>
<td>1</td>
<td>15,000.00</td>
<td>1</td>
<td>15,000.00</td>
</tr>
<tr>
<td>Soldador</td>
<td>Glb</td>
<td>1</td>
<td>12,000.00</td>
<td>1</td>
<td>12,000.00</td>
</tr>
<tr>
<td>Welder</td>
<td>Pza</td>
<td>20</td>
<td>450.00</td>
<td>1</td>
<td>9,000.00</td>
</tr>
<tr>
<td>Pallas</td>
<td>Pza</td>
<td>48</td>
<td>50.00</td>
<td>1</td>
<td>2,400.00</td>
</tr>
<tr>
<td>Picotes</td>
<td>Pza</td>
<td>36</td>
<td>55.00</td>
<td>1</td>
<td>1,980.00</td>
</tr>
<tr>
<td>Combs</td>
<td>Pza</td>
<td>6</td>
<td>150.00</td>
<td>1</td>
<td>1,080.00</td>
</tr>
<tr>
<td>Winches</td>
<td>Pza</td>
<td>1</td>
<td>1,200.00</td>
<td>4</td>
<td>1,200.00</td>
</tr>
<tr>
<td>Tips</td>
<td>Pza</td>
<td>12</td>
<td>30.00</td>
<td>1</td>
<td>360.00</td>
</tr>
<tr>
<td>Barretas</td>
<td>Pza</td>
<td>12</td>
<td>120.00</td>
<td>2</td>
<td>1,440.00</td>
</tr>
<tr>
<td>Patas de Cabra</td>
<td>Pza</td>
<td>8</td>
<td>180.00</td>
<td>3</td>
<td>1,080.00</td>
</tr>
<tr>
<td>Crowbars</td>
<td>Pza</td>
<td>2</td>
<td>210.00</td>
<td>2</td>
<td>420.00</td>
</tr>
<tr>
<td>Pulleys</td>
<td>Pza</td>
<td>2</td>
<td>350.00</td>
<td>2</td>
<td>700.00</td>
</tr>
<tr>
<td>Rope</td>
<td>ml</td>
<td>100</td>
<td>18.00</td>
<td>2</td>
<td>1,800.00</td>
</tr>
<tr>
<td>Barrels</td>
<td>Pza</td>
<td>10</td>
<td>150.00</td>
<td>1</td>
<td>1,500.00</td>
</tr>
<tr>
<td>Water tanks</td>
<td>Pza</td>
<td>1</td>
<td>4,500.00</td>
<td>5</td>
<td>4,500.00</td>
</tr>
<tr>
<td>Grifas</td>
<td>Pza</td>
<td>36</td>
<td>80.00</td>
<td>3</td>
<td>2,880.00</td>
</tr>
<tr>
<td>Hoses</td>
<td>ml</td>
<td>200</td>
<td>21.00</td>
<td>2</td>
<td>4,200.00</td>
</tr>
<tr>
<td>Drills</td>
<td>Pza</td>
<td>1</td>
<td>2,100.00</td>
<td>1</td>
<td>2,100.00</td>
</tr>
<tr>
<td>Grinders</td>
<td>Pza</td>
<td>2</td>
<td>2,500.00</td>
<td>1</td>
<td>5,000.00</td>
</tr>
<tr>
<td>Wrenches and Pliers</td>
<td>Pza</td>
<td>12</td>
<td>56.00</td>
<td>1</td>
<td>660.00</td>
</tr>
<tr>
<td>Pulleys Chains</td>
<td>Glb</td>
<td>1</td>
<td>8,000.00</td>
<td>3</td>
<td>8,000.00</td>
</tr>
<tr>
<td>Metal scaffolding</td>
<td>Pza</td>
<td>4</td>
<td>500.00</td>
<td>3</td>
<td>2,000.00</td>
</tr>
<tr>
<td>Others</td>
<td>Glb</td>
<td>1</td>
<td>11,000.00</td>
<td>1</td>
<td>11,000.00</td>
</tr>
<tr>
<td>Plumbing</td>
<td>Glb</td>
<td>1</td>
<td>3,500.00</td>
<td>3</td>
<td>3,500.00</td>
</tr>
<tr>
<td>Power</td>
<td>Glb</td>
<td>1</td>
<td>3,600.00</td>
<td>3</td>
<td>3,600.00</td>
</tr>
<tr>
<td>Tools</td>
<td>Glb</td>
<td>1</td>
<td>1,400.00</td>
<td>2</td>
<td>1,400.00</td>
</tr>
<tr>
<td><strong>TOTAL COST OF TOOLS AND MINOR EQUIPMENT Bs.</strong></td>
<td><strong>96,700.00</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The total cost of direct labor is:
Average Monthly Salary = 3,990.00 Bs. Number of workers = 60
Number of months / year = 12
Social charges = 69.13%

**SPM * CSN * Months * No. Workers = 1,985,847.47 Bs.**

The incidence of minor tools and equipment will be:

\[
j = \frac{96,700.0 \text{ Bs} \times 100\%}{1,985,847.47 \text{ Bs}}
\]

**TOOLS AND EQUIPMENT WEAR RETAIL = 5 %**

This item only calculate the percentage of the smaller tools used in the work:

**D. DIRECT COST**

Represents the sum of items (A + B + C), where:

A = Materials
B = Labor including the percentage of their social security contributions
C = Wear of tools and minor equipment.
E. GENERAL EXPENSES

In this area there are direct and indirect costs, as expressed in the following table: Overheads are an item within the engineering complex costs in their interpretation, not a percentage as indicated by many analysts, represents all costs demand a project and is specific for each work, being subject to the conditions of location (ubiquity), topography, climate, and magnitude of the project.

It is expressed as a percentage, only as a mathematician to distribute spending on each item or activity that makes up the project artifice.

**E.1 INDIRECT EXPENSES.** To calculate incidence heading "Overheads" will make an analysis of the costs or expenses demanded by a project, from the costs of preparing the presentation of the proposal, until delivery of the completed project.

**E.1.1 Bidding costs.** Considering participation in a tender process for any project should consider the following aspects:

**E.1.1.1 Purchase sheets.** The first expenditure incurred by a company is, the purchase of tender documents and technical specifications, flatter.

Purchase sheets represents in most projects 0.10% of the total amount of the work.

**ADVOCACY PURCHASE SHEETS = 0.10%**
E.1.1.2 Preparation of the proposal. - In preparing the proposal of one or more projects, considering preparation time of 25 calendar days. Mark time Basic Standards in the preparation of an offer Cost calculation day staff:

**PAYROLL**

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
<th>SALARY</th>
<th>EMPLOYER CONTRIBUTIONS</th>
<th>BONUS</th>
<th>VACATION</th>
<th>TOTAL CATTLE</th>
<th>DAY COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manager</td>
<td>15,000.00</td>
<td>2,250.00</td>
<td>1,250.00</td>
<td>625.00</td>
<td>19,125.00</td>
<td>637.50</td>
</tr>
<tr>
<td>2</td>
<td>Work director</td>
<td>10,000.00</td>
<td>1,500.00</td>
<td>833.33</td>
<td>416.67</td>
<td>12,750.00</td>
<td>425.00</td>
</tr>
<tr>
<td>3</td>
<td>Counter ¼ T</td>
<td>5,600.00</td>
<td>840.00</td>
<td>466.67</td>
<td>233.33</td>
<td>7,140.00</td>
<td>238.00</td>
</tr>
<tr>
<td>4</td>
<td>Secretary</td>
<td>4,000.00</td>
<td>600.00</td>
<td>333.33</td>
<td>166.67</td>
<td>5,100.00</td>
<td>170.00</td>
</tr>
<tr>
<td>5</td>
<td>Driver</td>
<td>4,000.00</td>
<td>600.00</td>
<td>333.33</td>
<td>166.67</td>
<td>5,100.00</td>
<td>170.00</td>
</tr>
<tr>
<td>6</td>
<td>Auxiliar</td>
<td>3,000.00</td>
<td>450.00</td>
<td>250.00</td>
<td>125.00</td>
<td>3,825.00</td>
<td>127.50</td>
</tr>
<tr>
<td>7</td>
<td>Serene</td>
<td>2,900.00</td>
<td>435.00</td>
<td>241.67</td>
<td>120.83</td>
<td>3,697.50</td>
<td>123.25</td>
</tr>
<tr>
<td>8</td>
<td>Foreman</td>
<td>6,300.00</td>
<td>945.00</td>
<td>525.00</td>
<td>262.50</td>
<td>8,032.50</td>
<td>267.75</td>
</tr>
</tbody>
</table>

**SUMMARY OF THE PREPARATION OF THE PROPOSAL**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>DAY COST(Bs)</th>
<th>PROJECT PREPARATION (DAYS)</th>
<th>TOTAL Bs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>425.00</td>
<td>25</td>
<td>10,625.00</td>
</tr>
<tr>
<td>Secretary</td>
<td>170.00</td>
<td>25</td>
<td>4,250.00</td>
</tr>
<tr>
<td>Auxiliar</td>
<td>127.50</td>
<td>25</td>
<td>3,187.50</td>
</tr>
<tr>
<td>TOTAL</td>
<td>Bs.</td>
<td></td>
<td>18,062.50</td>
</tr>
<tr>
<td>T/C</td>
<td>$us</td>
<td></td>
<td>2,595.19</td>
</tr>
</tbody>
</table>
Exchange Rate = 6.96 Bs. / $ Us.
Project Cost = $ 1,000,000.00 us
Runtime = 12 months

\[ i = \frac{2,595.19\text{us} * 100\%}{1,000,000.00 \text{us}} \]

**REASONING PREPARATION ADVOCACY = 0.26\%**

E.1.1.3 Preparation of legal documents.- The legal documents required by the Supreme Resolution No. 216145 dated August 3, 1995 through the Basic Rules Management System Goods and Services for the submission of a proposal are:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>COST IN $US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil engineering certificate</td>
<td>35.00</td>
</tr>
<tr>
<td>Certificate of CABOCO</td>
<td>10.00</td>
</tr>
<tr>
<td>Certificate of FUNDEMPRESA</td>
<td>45.00</td>
</tr>
<tr>
<td>Legalized NIT + memorial</td>
<td>70.00</td>
</tr>
<tr>
<td>Legalization Doc. Company</td>
<td>150.00</td>
</tr>
<tr>
<td>Photocopies proposal sets</td>
<td>75.00</td>
</tr>
<tr>
<td>Binding proposals</td>
<td>75.00</td>
</tr>
<tr>
<td>Others</td>
<td>150.00</td>
</tr>
</tbody>
</table>

**TOTAL** 610.00
Preparation of legal documents.

\[ i = \frac{610.00 \text{ $us} \times 100\%}{1,000,000.00 \text{ $us}} \]

**ADVOCACY FOR LEGAL DOCUMENTS = 0.06 %**

This value according to the incidence found in the preparation of legal documents required by the Basic Standard. It is to note that the documents required depend on the bidder Institution, which vary in cost and more information requested in the administrative specifications.

**E.1.1.4 Inspection of building site.** - In order to have a real concept of the magnitude of the project, the visit to the site where it will perform the work, in order to see the possibilities of supplies of materials, populated places, topography, climate, to this effect it is required it is necessary the engineer’s visit will prepare the proposal, accompanied by the foreman, demanding a day on this visit. Therefore you should calculate the impact of this visit on the cost of the proposal.

To this effect visit the engineer and the foreman using one day:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>DAY COST (BS)</th>
<th>PER DIEM BS.</th>
<th>TOTAL COST BS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>425.00</td>
<td>600.00</td>
<td>1,025.00</td>
</tr>
<tr>
<td>Foreman</td>
<td>267.75</td>
<td>415.00</td>
<td>682.75</td>
</tr>
<tr>
<td>Mobility Rental</td>
<td>1,740.00</td>
<td>-</td>
<td>1,740.00</td>
</tr>
<tr>
<td>Petrol 80 liters</td>
<td>374.00</td>
<td>-</td>
<td>374.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td><strong>Bs.</strong></td>
<td></td>
<td><strong>3,821.75</strong></td>
</tr>
<tr>
<td>T/C</td>
<td><strong>$us</strong></td>
<td></td>
<td><strong>549.10</strong></td>
</tr>
</tbody>
</table>

For our analysis of a project we consider:

\[ i = \frac{549.1 \text{ $us} \times 100\%}{1,000,000.00 \text{ $us}} \]

**ADVOCACY VISIT TO PLACE = 0.05 %**
### E.1.1.5 Issuance of Bid Security Proposal.
In the statement of terms of reference submitting a bid bond proposal for amounts and fixed term is established, the same institution that determines the bidding, most of this guarantee represents 0.10% of the amount of the work.

**ADVOCACY BID BOND PROPOSAL = 0.10 %**

### SUMMARY OF THE COST OF BIDDING

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>% COST OF THE INDIRECT COST BIDDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>PURCHASE SHEETS</td>
<td>0.10 %</td>
</tr>
<tr>
<td>PROPOSAL PREPARATION</td>
<td>0.26 %</td>
</tr>
<tr>
<td>PREP. LEGAL DOCUMENTS</td>
<td>0.06 %</td>
</tr>
<tr>
<td>SITE INSPECTION</td>
<td>0.05 %</td>
</tr>
<tr>
<td>RELIABILITY WARRANTY PROPOSAL</td>
<td>0.10 %</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>0.58 %</strong></td>
</tr>
</tbody>
</table>

### E.1.2 Cost Allocation.
Informed of the award to the company, by the contracting institution, the company must submit “The required guarantees, the same ones that have the character of irrevocable, renewable and immediate execution” Art. 511> Basic Standards for Property Management and Services These warranties are three in number:

**E.1.2.1 Contract Compliance.** An amount equal to 7.0% of the value of the budget submitted by the company, effective from signing the contract until final acceptance of the work.

**E.1.2.2 Advance right investment.** Whose amount will be equal to 100% of the advance that the contracting institution grant the company with effect from delivery of the advance until its full repayment date to be fixed in the contract. In case of works and consulting as redeemed over the amount of the advance, by the same percentage may be reduced warranty period keeping the original effective.

**E.1.2.3 Good performance.** A minimum of three (3) months and a maximum of twelve (12) months, depending on the characteristics of the work, by an amount equal to 10% of the amount will be required in case of construction works, effective from the final acceptance the budget submitted by the company, without prejudice to the awarded is called to answer for hidden defects that may exist in the work.
E.1.3. Office operating costs.- For a full discussion of the item “Overheads” it is necessary to conduct a study of the minimum requirements of an enterprise, for a’re in the market for the construction industry, must necessarily have one or more projects annually, to cover all expenses required maintaining an office where the position of a manager, accountant, secretary, assistant foreman, within heading personal services and the departure of basic services there.
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MONTHLY EXPENDITURE</th>
<th>ANNUAL EXPENDITURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal service</td>
<td>43,222.50</td>
<td>518,670.00</td>
</tr>
<tr>
<td>Manager</td>
<td>15,000.00</td>
<td>180,000.00</td>
</tr>
<tr>
<td>Counter ½ T.</td>
<td>5,600.00</td>
<td>67,200.00</td>
</tr>
<tr>
<td>Secretary</td>
<td>4,000.00</td>
<td>48,000.00</td>
</tr>
<tr>
<td>Assistant</td>
<td>3,000.00</td>
<td>36,000.00</td>
</tr>
<tr>
<td>Foreman</td>
<td>6,300.00</td>
<td>75,600.00</td>
</tr>
<tr>
<td>Bonus</td>
<td>2,825.00</td>
<td>33,900.00</td>
</tr>
<tr>
<td>Holiday</td>
<td>1,412.50</td>
<td>16,950.00</td>
</tr>
<tr>
<td>Employer contributions</td>
<td>5,085.00</td>
<td>61,020.00</td>
</tr>
<tr>
<td>Basic services</td>
<td>8,390.00</td>
<td>100,680.00</td>
</tr>
<tr>
<td>Office Rental</td>
<td>2,500.00</td>
<td>30,000.00</td>
</tr>
<tr>
<td>Furniture</td>
<td>900.00</td>
<td>10,800.00</td>
</tr>
<tr>
<td>Phone</td>
<td>500.00</td>
<td>6,000.00</td>
</tr>
<tr>
<td>Water</td>
<td>250.00</td>
<td>3,000.00</td>
</tr>
<tr>
<td>Electric power</td>
<td>450.00</td>
<td>5,400.00</td>
</tr>
<tr>
<td>Material Desktop</td>
<td>350.00</td>
<td>4,200.00</td>
</tr>
<tr>
<td>Computer</td>
<td>900.00</td>
<td>10,800.00</td>
</tr>
<tr>
<td>Newspaper</td>
<td>150.00</td>
<td>1,800.00</td>
</tr>
<tr>
<td>Tea service</td>
<td>600.00</td>
<td>7,200.00</td>
</tr>
<tr>
<td>Maintenance Ofi.</td>
<td>350.00</td>
<td>4,200.00</td>
</tr>
<tr>
<td>Office cleaning</td>
<td>280.00</td>
<td>3,360.00</td>
</tr>
<tr>
<td>Input CADECO</td>
<td>700.00</td>
<td>8,400.00</td>
</tr>
<tr>
<td>Municipal patent</td>
<td>120.00</td>
<td>1,440.00</td>
</tr>
<tr>
<td>Min patent. Trab.</td>
<td>210.00</td>
<td>2,520.00</td>
</tr>
<tr>
<td>P. FUNDEMPRESA</td>
<td>40.00</td>
<td>480.00</td>
</tr>
<tr>
<td>Others</td>
<td>90.00</td>
<td>1,080.00</td>
</tr>
<tr>
<td><strong>TOTAL Bs.</strong></td>
<td><strong>51,612.50</strong></td>
<td><strong>619,350.00</strong></td>
</tr>
<tr>
<td><strong>T/C $us.</strong></td>
<td><strong>7,415.59</strong></td>
<td><strong>88,987.07</strong></td>
</tr>
</tbody>
</table>
\[ i = \frac{88,987.00 \text{ $us} \times 100\%}{1,000,000.00 \text{ $us}} \]

**IMPACT OF OPERATION OFFICE** = 8.90 %

**E.2 DIRECT EXPENDITURE.**

To calculate incidence heading “Overheads” will make an analysis of the costs or expenses demanded by a project, from the costs of mobilization and demobilization of personnel and equipment, administrative costs of work and improvistos presented in the same.

**E.2.1 Mobilization and demobilization costs.**

For analysis, it is necessary to conduct a study of the minimum requirements required to mobilize and demobilize equipment and personnel to a certain place to perform the work in question.

**E.2.1.1 Mobilization and demobilization of equipment.** For the analysis of this item it is necessary to know the amount of equipment and small tools that will be used by the workers in the work, having the engineer in charge of the project to list all these for a specific project.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>COST $US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alquiler Truck</td>
<td>540.00</td>
</tr>
<tr>
<td>Small Truck Rental</td>
<td>375.00</td>
</tr>
<tr>
<td>Driver</td>
<td>114.94</td>
</tr>
<tr>
<td>Gas</td>
<td>268.68</td>
</tr>
<tr>
<td>Helpers</td>
<td>474.14</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,772.76</strong></td>
</tr>
</tbody>
</table>
E.2.1.2 Mobilization and demobilization of staff. - The analysis of this item will be determined by the engineer in charge of the project, according to its requirements where the number of workers participating in the project will be determined.

Exchange Rate = 6.96 Bs. / $ Us.
Cost per worker = 190.00 Bs. / Day US $ 27.30 / day
Number of workers = 60
Mobilization time = 2 days

\[
\text{Mov. Personal} = \text{DE ° Workers} \times \text{Cost per Worker}
\]

\[
\text{Mov. Personal} = 3,275.86 \, \text{US$}
\]

\[
\frac{3,275.68 \, \text{US$} \times 100\%}{1,000,000.00 \, \text{US$}} = \text{INCIDENCE MOV. Y NONMOV. PERSONAL} = 0.33\%
\]
Inspection time = 2 days

<table>
<thead>
<tr>
<th>PER DIEM</th>
<th>COSTO Bs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>7,650.00</td>
</tr>
<tr>
<td>Works Director</td>
<td>5,100.00</td>
</tr>
<tr>
<td>Assistant</td>
<td>1,530.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MOBILITY</th>
<th>COSTO Bs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeep Rental</td>
<td>10,440.00</td>
</tr>
<tr>
<td>Gas</td>
<td>3,590.40</td>
</tr>
<tr>
<td>Others (Com. Y Ref.)</td>
<td>6,000.00</td>
</tr>
</tbody>
</table>

TOTAL Bs. = 34,310.40

T/C $us = 4,929.66

\[
i = \frac{4,929.66 \text{ $us} \times 100\%}{1,000,000.00 \text{ $us}}
\]

INSPECTION OF EXECUTIVES = 0.49%

SUMMARY MOBILIZATION AND DEMOBILIZATION
EQUIPMENT AND PERSONNEL

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>INCIDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOBILE. AND NONMOV. EQUIPMENT</td>
<td>0.18 %</td>
</tr>
<tr>
<td>MOBILE. AND NONMOV. PERSONAL</td>
<td>0.33 %</td>
</tr>
<tr>
<td>INSPECTION OF EXECUTIVES</td>
<td>0.49 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1.00 %</td>
</tr>
</tbody>
</table>
E.2.2 administrative costs of work.- For the calculation of this item took into account the salaries of all executive personnel and plant work, nonpersonal services using the same operation and services of the work.

E.2.2.1 Personal Work.- We consider the executive staff and project plant, taking into account bonuses, employer contributions, vacation and improvisor thereof.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>COST MONTH</th>
<th>ANNUAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Works Director</td>
<td>12,750.00</td>
<td>153,000.00</td>
</tr>
<tr>
<td>Counter ½ T.</td>
<td>7,140.00</td>
<td>85,680.00</td>
</tr>
<tr>
<td>Auxiliar</td>
<td>3,825.00</td>
<td>45,900.00</td>
</tr>
<tr>
<td>Foreman</td>
<td>8,032.50</td>
<td>96,390.00</td>
</tr>
<tr>
<td>Serene</td>
<td>3,697.50</td>
<td>44,370.00</td>
</tr>
<tr>
<td><strong>TOTAL Bs. =</strong></td>
<td><strong>35,445.00</strong></td>
<td><strong>425,340.00</strong></td>
</tr>
<tr>
<td>T/C $us =</td>
<td>5,092.67</td>
<td>61,112.07</td>
</tr>
</tbody>
</table>

E.2.2.2 nonpersonal services.- For the calculation are considered basic services, food and stationery executive and plant staff involved in the project.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>COST MONTH</th>
<th>ANNUAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone</td>
<td>700.00</td>
<td>8,400.00</td>
</tr>
<tr>
<td>Water</td>
<td>1,200.00</td>
<td>14,400.00</td>
</tr>
<tr>
<td>Electric power</td>
<td>1,800.00</td>
<td>21,600.00</td>
</tr>
<tr>
<td>Tea</td>
<td>350.00</td>
<td>4,200.00</td>
</tr>
<tr>
<td>Material Desk</td>
<td>420.00</td>
<td>5,040.00</td>
</tr>
<tr>
<td>Furniture</td>
<td>800.00</td>
<td>9,600.00</td>
</tr>
<tr>
<td>Incidents</td>
<td>700.00</td>
<td>8,400.00</td>
</tr>
<tr>
<td><strong>TOTAL Bs. =</strong></td>
<td><strong>5,970.00</strong></td>
<td><strong>71,640.00</strong></td>
</tr>
<tr>
<td>T/C $us =</td>
<td>857.76</td>
<td>10,293.10</td>
</tr>
</tbody>
</table>
E.2.2.3 Operation services.- They are taken into account for the calculation of this item laboratory tests, expenses, computer equipment and light vehicles.

### Operation Services Costs

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>COST MONTH</th>
<th>ANNUAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Testing</td>
<td>1,200.00</td>
<td>14,400.00</td>
</tr>
<tr>
<td>Computer equipment</td>
<td>700.00</td>
<td>8,400.00</td>
</tr>
<tr>
<td>Light vehicle</td>
<td>1,400.00</td>
<td>16,800.00</td>
</tr>
<tr>
<td>Gas</td>
<td>600.00</td>
<td>7,200.00</td>
</tr>
<tr>
<td>Representation expenses</td>
<td>600.00</td>
<td>7,200.00</td>
</tr>
<tr>
<td>TOTAL Bs. =</td>
<td>4,500.00</td>
<td>54,000.00</td>
</tr>
<tr>
<td>T/C $us =</td>
<td>646.55</td>
<td>7,758.62</td>
</tr>
</tbody>
</table>

\[
i = \frac{(61,112.07 + 10,293.10 + 7,758.62)\, \text{ SUS} \times 100\%}{1,000,000.00 \, \text{ SUS}}
\]

COST IMPACT ADM. WORKING = 7.92 %

E.2.3 Unforeseen costs.- Within this item we consider medical care, accidents, and theft kits that may arise in the execution of the work.

### Unforeseen Costs

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>COST $US</th>
<th>% INCIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical care</td>
<td>1800.00</td>
<td>0.18 %</td>
</tr>
<tr>
<td>Thefts</td>
<td>500.00</td>
<td>0.05 %</td>
</tr>
<tr>
<td>Accidents</td>
<td>500.00</td>
<td>0.05 %</td>
</tr>
<tr>
<td>First aid kit</td>
<td>350.00</td>
<td>0.04 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>0.32 %</td>
</tr>
</tbody>
</table>

CONTINGENCY FEE = 0.32 %
The sum of these items encloses the large overheads, whose total value divided by the direct cost of the work gives results the percentage to be distributed in each item of the project, resulting according to the cost structure, the cost net activity or item.

### GENERAL SUMMARY OF THE OVERHEAD

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>% INCIDENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDIRECT COSTS</td>
<td></td>
</tr>
<tr>
<td>Bidding costs</td>
<td>0.58 %</td>
</tr>
<tr>
<td>Award costs</td>
<td>2.97 %</td>
</tr>
<tr>
<td>Operating costs in office</td>
<td>8.90 %</td>
</tr>
<tr>
<td><strong>DIRECT COSTS</strong></td>
<td></td>
</tr>
<tr>
<td>Mov cost. And Desmov. Equipment.</td>
<td>1.00 %</td>
</tr>
<tr>
<td>Administration costs on site</td>
<td>7.92 %</td>
</tr>
<tr>
<td>Unforeseen costs</td>
<td>0.32 %</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>21.67 %</td>
</tr>
</tbody>
</table>

**GENERAL EXPENSES = 21.67%**

### F. NET COST OF ITEM

It is the value or cost of an item without considering profits pursued by the company and the tax burden as a percentage determined according to laws and regulations.

### G. UTILITY COMPANY

Political 156th State Constitution in his 7th section, subsection d) Art., Empowers everyone the fundamental right to work and engage in commerce for legal purposes also the commercial code by Decree Law No. 14379 dated January 10, 1978, Art. 4th, says the concept of trader as a person or institution dedicated to conduct commercial activity for profit, Art. the 6th says “are acts and trading operations, paragraph 16, business activity construction and buildings in general.”

Therefore in the cost structure of the item or category called “utility”, the same that determines each company according to their persecuted utility should appear.
According to the conditions, difficulty of the work, this percentage usually ranges from 10% to at least 30% maximum.

**H. TAXES**

Finally, to establish the market retail price of an item to be incorporated in the cost analysis, tax burdens; taxes determined by law 846, regulated by Supreme Decree No. 21530 and amendments by Law 1606 of December 22, 1994, which clearly expresses the concept of VALUE ADDED TAX (VAT) and TAX TRANSACTIONS (TT), and Supreme Decree No. 24692 of July 2, 1997.

**H.1 Value added tax (VAT).** The value added tax (VAT) is a tax that falls directly to the consumer of goods and services and is regulated with a percentage of 13% in the aforementioned Law. In the construction industry the costs of labor, do not provide any tax credit to the company therefore should be considered on the total cost of labor the value added tax (VAT).

**Data:**
- Cost of labor = A
- Value added tax (VAT) = B
- Total cost of labor = C

**Where:**

\[ C = A + B \] (1)

**However:**

\[ B = \text{VAT (13%)} \text{ of the cost of labor} \]
\[ B = 0.13 \times C \] (2)

Substituting in equation (1) equation (2) we have:

\[ C = A + (0.13 \times C) \]

**Punting A:**

\[ A = 0.87 \times C \] (3)

**Given that the cost of labor used**

\[ A = 100 \% \text{ Substituting in equation (3) we have:} \]
\[ 100 = 0.87 \times C \]

**Punting C:**

\[ C = \frac{100}{0.87} \]
\[ C = 114.94 \]

**VALUE-ADDED TAX (VAT) = 14.94 %**
Replacing the value of $C$ in equation (2)

\[ B = 0.13 \times 114.94 \]
\[ B = 14.94\% \]

**H.2 Transaction tax (TT).-** No. 1606 Law amending the Law 843 in its Art. 75 determines a general rate of 3%, which falls on the owners of the NIT. For its activities in the industry in general, representing a blind tax, which must be embedded within the context of the cost structure. This transaction tax (TT) is levied on gross income earned from the exercise of any gainful activity, and should be considered in the analysis of the cost structure.

**Data:**
- Total cost of the item = $C$
- Compensation (TT) = $B$
- Transaction price = $A$

**Where:**
\[ A = B + C \quad (1) \]

**We must find a percentage (X) such that:**
\[ B = X \times C \quad (2) \]

The national exchequer should pay 3% as Law 843 of the transaction price ($A$) points and this must be equal to the offset value ($B$)

**Therefore:**
\[ B = 0.03 \times A \quad (3) \]

**Substituting into equation (3) into equation (2) we have:**
\[ A = B + C \]
\[ A = 0.03 \times A + C \]

**Clearing the total cost of the item are:**
\[ C = 0.97 \times A \]

**From equation (2) cleared X:**
\[ X = \frac{B}{C} \]
\[ X = \left( \frac{0.03 \times A}{0.97 \times A} \right) \]
\[ X = 0.0309 \times 100\% \]
\[ X = 3.09\% \]
1. RETAIL PRICE MARKET ITEM

It represents that an item has been delivered to the market, being this way the completed structure engineering costs in the field of building industry.

TRANSACTION TAX (TT) = 3.09
**ANALYSIS UNIT PRICE**

**PROJECT: 1**

**Activity: 1 - 6H BRICK WALL  E = 0.12 (24X18X12)**

**Unit:** M2  
**Quantity:** 1.00  
**Currency:** Bs

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price</th>
<th>Unproductive</th>
<th>Productive</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MATERIALS</td>
<td>M3</td>
<td>0.050000</td>
<td>137.50</td>
<td>6.875</td>
<td>12.760</td>
<td>50.885</td>
</tr>
<tr>
<td>F relations</td>
<td>KG</td>
<td>11.00000</td>
<td>1.160</td>
<td></td>
<td>1.250</td>
<td>2.500</td>
</tr>
<tr>
<td>CEMENT, VIACELA</td>
<td>PZA</td>
<td>25.00000</td>
<td>1.500</td>
<td></td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>HOLLOW BRICK, 6 24X18X12</td>
<td>HR</td>
<td>1.000000</td>
<td>22.500</td>
<td>35.750</td>
<td>35.750</td>
<td>71.500</td>
</tr>
<tr>
<td>2. WORKFORCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUILDER</td>
<td>HR</td>
<td>1.500000</td>
<td>13.750</td>
<td>24.063</td>
<td>24.063</td>
<td>58.133</td>
</tr>
<tr>
<td>ASSISTANT</td>
<td>HR</td>
<td>1.750000</td>
<td>5.000</td>
<td>0.000</td>
<td>0.000</td>
<td>5.000</td>
</tr>
<tr>
<td>SOCIAL BENEFITS - %</td>
<td>HR</td>
<td>0.100000</td>
<td>100.00</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3. TOOLS AND EQUIPMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOOLS - %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONCRETE MIXER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. GENERAL EXPENSES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVERHEAD - % OF DIRECT COST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UTILITY - % OF (1 + 2 + 3 + AD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. TAXES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VALUE ADDED TAX (VAT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRANSACTION TAX (CT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL OVERHEADS:** 19.409  
**TOTAL TOOLS AND EQUIPMENT:** 5.591  
**TOTAL UNIT PRICE:** 125.497
## Analysis Unit Price

### Project: 1

**Activity:** 1 - 6H Brick Wall, $E = 0.12$ (24X18X12)  
**Unit:** M2  
**Quantity:** 1.00  
**Currency:** Bs

### 1. Materials

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Percentage</th>
<th>Price Unproductive</th>
<th>Price</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINA ARENA</td>
<td>M3</td>
<td>0.05000</td>
<td></td>
<td>137.500</td>
<td></td>
<td>6.875</td>
<td></td>
</tr>
<tr>
<td>CEMENT VIACHA</td>
<td>KG</td>
<td>11.00000</td>
<td></td>
<td>1.160</td>
<td>12.760</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLLOW BRICK 6 24X12X18</td>
<td>PZA</td>
<td>25.00000</td>
<td></td>
<td>1.250</td>
<td>31.250</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50.885</td>
<td></td>
</tr>
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</table>

### 2. Workforce

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Percentage</th>
<th>Price</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDER</td>
<td>HR.</td>
<td>1.50000</td>
<td></td>
<td>22.500</td>
<td>33.750</td>
<td></td>
</tr>
<tr>
<td>ASSISTANT</td>
<td>HR.</td>
<td>1.75000</td>
<td></td>
<td>13.750</td>
<td>24.063</td>
<td></td>
</tr>
<tr>
<td><strong>Social Benefits - %</strong></td>
<td></td>
<td></td>
<td></td>
<td>69.13%</td>
<td>39.966</td>
<td></td>
</tr>
<tr>
<td><strong>Total Workforce</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>97.778</td>
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</table>

### 3. Tools and Equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Percentage</th>
<th>Price</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOOLS - %</td>
<td></td>
<td></td>
<td></td>
<td>5.00%</td>
<td>2.891</td>
<td></td>
</tr>
<tr>
<td>CONCRETE MIXER</td>
<td>IIR.</td>
<td>0.10000</td>
<td>100.00%</td>
<td>25.000</td>
<td>25.000</td>
<td>2.500</td>
</tr>
<tr>
<td><strong>Total Tools and Equipment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.301</td>
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</tbody>
</table>

### 4. General Expenses

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead - % of Direct Cost</td>
<td></td>
<td>21.67%</td>
<td>33.383</td>
</tr>
<tr>
<td>Utility - % of (1 + 2 + 3 + ADM.)</td>
<td></td>
<td>10.00%</td>
<td>18.744</td>
</tr>
<tr>
<td><strong>Total Overheads</strong></td>
<td></td>
<td></td>
<td>52.127</td>
</tr>
</tbody>
</table>

### 5. Taxes

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value Added Tax (VAT) - % of (2 + 3)</td>
<td></td>
<td>14.94%</td>
<td>15.413</td>
</tr>
<tr>
<td>Transaction Tax (TT) - % of Total</td>
<td></td>
<td>3.09%</td>
<td>0.852</td>
</tr>
<tr>
<td><strong>Total Tax</strong></td>
<td></td>
<td></td>
<td>22.265</td>
</tr>
<tr>
<td><strong>Total Unit Price</strong></td>
<td></td>
<td></td>
<td>228.446</td>
</tr>
</tbody>
</table>


Implementation of a PMO at LA Metro

Brian James Boudreau¹, Julie K. Owen, CCP PSP², and Michael Edward Williams³

¹ LA Metro, boudreaub@metro.net
² LA Metro, owenj@metro.net
³ LA Metro, williamsmi@metro.net

ABSTRACT

Measure R is a sales tax ordinance approved by the voters of Los Angeles County that commits $36 billion over 30 years to transportation initiatives that combat regional traffic congestion. Due to the size and scope of the program, LA Metro (Metro) implemented a Program Management Office (PMO) business unit to promote successful program delivery and provide accountability. The PMO department provides support in project control, portfolio management, project management standards, training, and process improvement.

This paper discusses the benefits of implementing the Program Management Office including the following:

- Supporting controls across the project lifecycle including estimating, configuration management, and project controls
- Providing program and project risk transparency
- Promoting best practice management for expediting project delivery
- Facilitating external industry and peer reviews to accelerate project delivery
- Delivering enterprise-wide project management tools to provide timely reporting
- Instituting performance management processes and metrics to achieve targets
- Offering training programs to improve Metro project management capabilities
- Communicating the value proposition to executive management.
Introduction

The Los Angeles County Metropolitan Transportation Authority (Metro) is responsible for the continuous improvement of an efficient and effective transportation system for Los Angeles County. This mission has been challenged in recent years by continuous population growth that stressed existing infrastructure and would continue to do so for decades to come unless significant investment was made to the county’s rail and highway system.

LA County is the most populous county in the United States and Metro manages a service area more than 1,433 mi² and across eighty-eight cities. LA County’s population from 2004 to 2040 is anticipated to grow by 33%, with the broader region expected to increase in population by 44% to 24.6 million people. Without investment in transportation infrastructure, this growing congestion is expected to worsen. Based upon studies, average freeway speeds are expected to drop by 16 miles per hour by 2040, again driven by population growth.

With the increased population, and expected growth in automobile usage, air quality and environmental impact is also a growing concern. Significant investments were made to LA County’s transportation infrastructure in the 1980s and parts of the 1990s, but more recently, funding for capital improvement projects had been insufficient to match the growing transportation demands of the community. In recognition of the transportation needs, LA County voters passed “Measure R” in November 2008. [1]

Background

Measure R provides Metro with a potential $36 billion in revenue to support improving transportation improvements in the Los Angeles basin. Funds from Measure R, which will be provided through a ½¢ increase in sales tax, will allow Metro to fund a number of projects over the 30-year period the measure is in effect. Measure R represents the largest public works program within the United States and due to the sheer size and complexity of the program, the Metro Board initiated studies and directives to position the program for success.

A Board Motion in December 2009 highlighted key process areas for review by an industry review panel comparing Metro to other major transportation agencies. Review areas included transportation best practices, procurement, construction, project management, audit, organizational development, and funding. An additional requirement included researching opportunities for securing additional funding and financing. These recommendations were developed by Parsons Brinckerhoff (PB) in the June 2010 report.

The PB Report evaluated Metro’s policies, procedures, practices, and organizational structure to ensure the agency could deliver the ballot initiative projects in the fastest possible time frame without institutional barriers. The report identified nine categories of recommendations, one of which was establishing a Program Management Office, which stated “there needs to be strong leadership and a dedicated, central point of coordination at Metro for acceleration of Measure R. To fully implement the acceleration of the Measure R program, there is a need to end departmental silos and project handoffs, and provide a more integrated and holistic approach to project delivery for the Measure R projects.”[2]
In September 2010, a leadership position was added via a revised organizational structure to create an autonomous Program Management Office (PMO). The PMO is a business unit reporting directly to the Deputy Chief Executive Officer with the driving mission to provide an early warning of issues and risks that may impact the budget or schedule of capital projects. The unit is subdivided into functional divisions that are split between project and program activities. The unit comprises two functional divisions, one for project control and one for program control. The organizational chart is depicted below in Figure 1.

The overall charter for the PMO business unit involves providing project controls support for activities including estimating, configuration management, cost, and schedule controls. In addition, program controls support is provided for portfolio management, project management standards, training, and process improvement.

Benefits and Value of Program Management Office

Providing Project Controls Support Across the Project Lifecycle

One of the benefits of the PMO is providing matrixed subject matter expert support for project controls to the project management team across the project lifecycle. The project controls department was originally created in the 1990s for transit projects and is embedded within institutional policy and procedure where it remains a required skill set supporting project management. Staffs are technical subject matter experts educated in transit industry best practices and responsible for configuration management, estimating, and project control functions for capital projects across their project lifecycle.

The configuration management section facilitates both project document and contract change administration. These functions include maintaining the official project record documents for
the contract, managing electronic document exchange including facilitating Metro response, and administering contract changes. In addition, the configuration management section functions institutionally by administering organizational design standards and procedures, maintaining configuration management of document revisions, and managing the change control review board. Section functional procedures are listed below in Table 1:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF01</td>
<td>Configuration Management Plan</td>
</tr>
<tr>
<td>CF02</td>
<td>Baseline Documents</td>
</tr>
<tr>
<td>CF03</td>
<td>Formatting and Identification Standards</td>
</tr>
<tr>
<td>CF04</td>
<td>Contractor Submittal Processing</td>
</tr>
<tr>
<td>CF05</td>
<td>As-built Document Processing</td>
</tr>
<tr>
<td>CF06</td>
<td>Contract Closeout: Transfer of Records</td>
</tr>
<tr>
<td>CF07</td>
<td>Revision Control for Procedures</td>
</tr>
<tr>
<td>CF08</td>
<td>System-wide Baseline Documents</td>
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<tr>
<td>CF09</td>
<td>Contract Design Changes</td>
</tr>
<tr>
<td>CF12</td>
<td>File Subject Codes</td>
</tr>
<tr>
<td>CF13</td>
<td>Correspondence and Document Control</td>
</tr>
<tr>
<td>CF14</td>
<td>Construction Procurement Contracts</td>
</tr>
<tr>
<td>CF15</td>
<td>Rail Operation Configuration Change Control</td>
</tr>
<tr>
<td>CF16</td>
<td>Electronic Data Acceptance and Storage</td>
</tr>
</tbody>
</table>

Table 1 — Metro Configuration Management Section Procedures

The cost estimating section is responsible for developing cost estimates for capital projects across their lifecycle in planning, engineering, construction, and closeout. The cost estimating section maintains the organizational cost database for parametric analysis purposes and cost risk management.

The project controls section provides a functional manager to lead the team and manage cost, schedule, and risk of capital projects. The lead serves as the right hand to the project manager and is the key voice in all project control matters. The team contains subject matter experts in schedule, cost, risk, and claims. They are jointly responsible for early identification of cost or schedule risks or drivers that affect the budget or schedule. The cost team manages budgets, controls cost, assures quality control of financial information, analyzes cost drivers, performs trend analysis, and provides cost forecasts. The schedule team manages summary, control, and detailed schedules for the design and construction phases and is responsible for identifying any problems related to schedule performance while analyzing delay claims and mitigation plans.
The team conducts internal project risk assessments and verifies that cost and schedule are compliant with department risk and contingency management procedures. [5] All of the sections above work collaboratively as a group to provide proactive project management for capital projects for strategic execution. Projects are managed following project control procedures that are modeled after Federal Transit Administration (FTA) requirements and based upon transit industry best practices irrespective of whether they are FTA funded or not. As a result, FTA views Metro as one of the most mature grantees for federal transit projects. The complete list of transit project control procedures is shown below in Table 2:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRCL01</td>
<td>Work Breakdown Structure</td>
</tr>
<tr>
<td>PRCL02</td>
<td>Project Budget</td>
</tr>
<tr>
<td>PRCL03</td>
<td>Cost Estimating</td>
</tr>
<tr>
<td>PRCL04</td>
<td>Project Management Plan</td>
</tr>
<tr>
<td>PRCL05</td>
<td>Project Cost Reporting and Cost Forecasting</td>
</tr>
<tr>
<td>PRCL06</td>
<td>Performance Measurement/Engineering Progress</td>
</tr>
<tr>
<td>PRCL07</td>
<td>Risk Management</td>
</tr>
<tr>
<td>PRCL08</td>
<td>Cash Flow Plans</td>
</tr>
<tr>
<td>PRCL09</td>
<td>Schedule Development and Control</td>
</tr>
<tr>
<td>PRCL10</td>
<td>Physical Progress Monitoring</td>
</tr>
<tr>
<td>PRCL12</td>
<td>Project Contingency</td>
</tr>
</tbody>
</table>

**Table 2 — Metro Project Control Section Procedures**

In the past, Project Controls was organized under the Construction Division, which resulted in delayed or masked notification of potential problems. Project controls staff reported to project managers who had the final word on identifying risks or potential problems for their projects. Sometimes attempts by project controls staff to identify problems were delayed and/or softened. The Board of Directors required a new organizational structure to obtain early warning of problems and secure mitigation opportunities of cost and schedule risks.

The new organizational structure provided a direct project controls reporting line to the Chief Executive Office. This elevated the importance of project controls and promoted autonomy of the department to provide early warning of potential risks and issues. This structure provides executive level attention for identified project risks and promotes mitigation opportunities. This organizational structure and allocation of appropriate project control staff to projects provides value to the agency and stakeholders through early identification of cost and schedule problems so that mitigation measures can be implemented.
Providing Program Controls Support

Program controls staff performs program reporting, develop enterprise standards and tools, provide project management training and facilitate process improvements. To date one fulltime position was allocated for program control. Staffs are partially augmented by consultants in areas of program reporting, enterprise tools, and project management training where funding was provided. Process improvement and enterprise standards will be developed upon allocation of funding or allocation of staff. For more information related to program controls support, refer to lessons learned.

Providing Program and Project Risk Transparency

As mentioned previously, Metro project controls are mature after decades of delivering many transit capital projects while following Federal Transit Administration Oversight Procedure (FTA) (OP) guidelines. Metro transit project delivery project control procedures are based upon FTA OP guidelines as required by federal legislation for the Safe, Accountable, Flexible, Efficient Transportation Equity Act (SAFETEA-LU) and Moving Ahead for Progress in the 21st Century Act (MAP-21). FTA OP guidelines specify reporting and oversight requirements for grantees that request funds from the government and requirements during project delivery.

One such requirement mandates detailed risk assessments to be held over the transit project lifecycle. The FTA risk assessment guidelines prescribe detailed risk analysis workshops across project lifecycle and accompanying gate reviews are performed in conjunction with FTA managing personnel. Risk registers are prepared and updated on a monthly basis and risk threats are reported against available cost and schedule contingencies. Requirements related to cost and schedule contingency are specifically addressed within Metro policy and procedure. [6] In addition, the FTA appoints a Project Management Oversight Committee PMOC that is responsible for monthly management review. The FTA PMOC comprises transit industry discipline experts skilled in risks associated with transit projects. Lifecycle reviews are held at stage gates and hold points are established requiring FTA approval before entering the next project phase. At each phase, cost and schedule contingency targets are specified. Schedule contingency requirements are defined as 20% of the project duration from final design to revenue service (when the project opens to the public). The required FTA cost contingency levels across the project lifecycle are shown in Figure 2. During project phase gate reviews as specified below, the available contingencies are compared to required targets and projects must explain any deviation from requirements.
Programmatic risk management represents a new requirement established by the Board of Directors for early warning of potential threats to successful delivery. In this case, risk assessments are performed at the program level to ascertain threats that affect all projects in lieu of one project at a time. Three key areas targeted involve providing program risk policy and procedure guidance, conducting portfolio programmatic risk assessments, and facilitating lessons learned from completed projects.

Programmatic risk is a developing functional area within the Program Management Office that is not yet fully implemented. There are many opportunities for improvements related to programmatic risk. There are institutional risks related to delivering multiple mega programs and managing competing priorities. One such risk is managing third parties. Utilities and municipal entities represent other project stakeholders that impact program cost. These third parties may impact numerous projects and can impact overall program performance. Strategies are necessary where possible to orchestrate global cooperative agreements and partnering to facilitate proactive management.

One example of a recently performed programmatic risk study included procuring catastrophic risk insurance for the agency for in-process construction projects. Next year, Metro has approximately $10 Billion worth of projects in construction and several with the same contractor. Through studies it was determined there was a financial risk to the agency due to potential catastrophe that could result in contractor non-performance creating agency liabilities. Metro was successful in procuring catastrophic risk insurance.
insurance to mitigate potential earthquake specific risk. Additionally, Metro began experiencing higher than anticipated bid prices for construction projects and undertook a comprehensive study to determine the cause. An industry review highlighted key areas where contract requirements needed to be reevaluated in order to mitigate risk and reduce costs.

_Promoting Best Practice Management for Expedited Project Delivery_

A large portion of the aforementioned PB Report was focused on expediting project delivery. At that time, Metro delivered most projects with design-bid-build methodology. With the inception of Measure R, Metro entered a new era where most projects were mega projects over $100 million and public expectations involved project acceleration.

Industry advisor groups were enacted that provided project delivery advice to support acceleration based upon successful delivery of mega projects by other agencies. Studies of other large capital programs such as the Salt Lake Olympics in the United States, reflected creation of mega-projects and project delivery based upon design-build methodology. The driving benefits of design-build methodology were accelerated project delivery with reduced design risk to Metro and enhanced conflict management and decision making. Figure 3 below depicts the projected schedule savings related to projects delivered via design-build.

![Figure 3 – Design-Build Project Delivery Analysis](image-url)
Not all capital projects at Metro are delivered using design-build methodology. The majority of smaller capital projects are delivered design-bid-build methodology as preferred by smaller contracting firms. Additional studies are underway to evaluate the viability of other delivery methods such as public private partnerships (PPP), especially within the Measure R highway program.

**Facilitating External Industry Peer Reviews to Expedite Project Delivery**

Metro is quite active in the use of industry peer reviews for both project and program controls to assist in policy and decision making. Project peer reviews are regularly held with industry experts to review the scope, contract packaging, phasing, etc. related to projects before they enter the bid process. Peer reviews typically take place six months before the bid process begins. Feedback from the industry is invaluable as it especially helps reduce cost and opens dialog to alternatives that reduce risk and accelerate projects. Intriguingly, firms interested in bidding mega projects are overwhelmingly in favor of design-build methodology. Subsequently, peer review feedback is routinely incorporated into project bid packages. Peer reviews also occur at the program level through industry roundtable events. For example, Metro and Los Angeles Associated General Contractor (AGC) executives meet on a monthly basis to discuss upcoming projects and cost reduction strategies.

Recently, Metro noticed a trend of higher than estimated bid prices for construction projects. Industry experts were retained to study the cause and effect of higher prices and offer recommendations for changes to Metro programs and policies. [7] Studies and interviews were held with contracting firms to determine the cause of higher prices. Industry experts identified that bidding multiple design/build mega projects over the course of a year had reduced the pool of potential firms with bonding capacity and organizational capabilities to deliver the mega projects. This factor had attributed to higher bid prices. Contracting community interviews also highlighted increased bid prices due to Los Angeles specific sustainability policies. Social policies were implemented for the business community that required union labor agreements, local job hire programs, minority and disadvantaged business incentives, and employing disabled veterans. However, well intentioned, adherence to these policies increased project risk and increased prices. Finally, the contracting community identified challenges related to prompt payment and processing of contract changes. As a result of studies, Metro implemented changes to address some of the factors noted in the analysis. [8]

**Delivering Enterprise-Wide Project Management Tools to Provide Timely Reporting**

Metro deployed a Program Management Information System (PMIS) to facilitate program-wide project tracking, administration and management reporting. PMIS was implemented to maximize efficiencies through automation, standardization, and provide program performance transparency. [9] The system utilizes the latest version of Oracle® Primavera software that has been configured to support the program-wide reporting requirements. Software applications include Oracle® Primavera P6™ Professional, Oracle Primavera P6 Enterprise Project Portfolio Management (EPPM), Oracle Primavera Contract Management (CM13), Microsoft® SharePoint®, and EcoSys® EPC. All applications are integrated to the organizational financial system in Oracle® E-Business Suite. The system architecture is shown below in Figure 4:

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1Microsoft and SharePoint are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.
The Oracle Primavera P6 Professional application serves as the primary application for planning, scheduling and resource management. Oracle P6 EPPM Web serves a central role in supporting summary level reporting and facilitating communication. Key aspects of this application include portfolio level dashboards, executive scorecards, and risk and issue tracking. The Oracle CM13 application manages contract deliverables for major contracts and provides document management and change control capabilities. Contract reporting capabilities are available for document logs and include trend, cost, and variance reporting. The SharePoint application serves as the configuration management internal repository for all CM13 documents. Additionally, SharePoint contains an external repository where configuration controlled documents are managed related to corporate procedures, design criteria standards, standard specifications, and design variance requests. The EcoSys EPC application is the centralized cost repository that is automated to all other systems for financial data integration. The EcoSys EPC application is utilized for all cost reporting for budget, actuals, forecast, and labor reporting. Project scope and status data is integrated from P6 and EcoSys and published monthly to a public facing dashboard at www.metro.net on a monthly basis as shown in Figure 5 below. For more information and monthly status updates refer to https://mtadash.mlmprojectservices.com/

Figure 4 – PMIS General System Architecture
Instituting Performance Management Processes and Metrics to Achieve Targets

Building a fully functional PMO at both the project and program level requires targeting multiple goals simultaneously. As Rad and Levin (2007) describe it, “a fully functional enterprise program management office (EPMO) would provide tools, techniques, and principles to the project team for project cost, schedule, scope, and quality. In addition, the EPMO would provide tools and techniques to the portfolio team for project prioritization, midstream evaluation, and strategic alignment.” [10] Further, the spectrum of functional activities would include both team and enterprise focused activities. Team focused activities are characterized as having a short term immediate impact on the project while enterprise focused activities are global, proactive, and primarily long range or strategic. The deciding factor between the proportions of activities performed, either project or enterprise oriented, is marked by the organization’s level of project management maturity. In mature organizations, the EPMO becomes the focal point for project management improvements through implementation of enterprise-oriented functions that target program performance, identify key risks and issues, and communicate lessons learned.

Metro has begun key performance indicator (KPI) reporting for capital projects and is working with executive management stakeholders to enhance the range of desired indices. Currently, program management collects KPI project performance data for projects in construction. Tracked KPIs include a red-yellow-green evaluation of whether projects are behind schedule, on schedule, or ahead of schedule as well as on budget, over budget, or under budget. All KPIs within Metro’s PMO are presently tracked manually. The goal is that PMIS will auto-generate KPI reports for executives. Examples of these tracked KPIs are evident in the program management monthly report to the Board of Directors shown in Figure 6 below:
All KPIs currently identified are at the project level and none at the portfolio or program level. Two new KPIs for consideration by executives include percent of current budget increase over original adopted budget or percent costs versus percent contingency. These indicators would emphasize whether or not projects and programs are managed within allowable parameters. A few KPIs specific for program management consideration include percentage of project managers trained, number of enterprise procedures issued, portfolio level reports delivered, etc.

**Offering Training Programs to Improve Metro Project Management Capabilities**

A key component required for the PMO organizationally is training project managers. According to Rad (2001), “A PMO can be a very effective organizational tool in defining and implementing competency standards for project managers. The determination of desired competencies of project managers is highly influenced by organizational needs, strategies, and culture”. [11] As per Jose Angelo Santos do Valle (2008), “the PMO provides standardization, procedure, and templates, orientation, training, support to project management processes in the organization.” [12]

Metro implemented a Project Management Training Academy, which is offered quarterly with the underlying goal to improve project management capabilities. Previously institutional project manager training did not exist. Motivation for the training program consists of improving the knowledge base of project managers and keeping current with industry-wide best practices. The training program consists of a comprehensive two-day training program, which teaches basic project management elements in accordance with Metro procedures. Conceptually, the course contains tailored content for each major capital project type and/or business unit. The course highlights key facts related to project funding, planning, monitoring and control, project control systems, ethics, working with the Board of Directors, quality management, accounting, risk management, community relations, and estimating. The goal of Metro's Project Management Training Academy is to ensure projects are being delivered consistently and successfully by qualified project managers.
Communicating the Value Proposition to Executive Management

The main reason the PMO was created, as identified in the September 2010 Metro Board report, was to break down departmental silos and improve the workflow as projects progressed through developmental phases. Previously project managers were identified by department for projects (i.e., planning, engineering, construction, and operations). As projects progressed through the project lifecycle and project managers changed, confusion would then ensue and sometimes delay between phases. The Board determined that a single responsible manager was preferred to improve communication and continuity across the lifecycle.

The PMO was established as a central point of collaboration envisioned to work amongst departments and enhance lifecycle project management. A single responsible functional manager was assigned for each major project for continuity and coordination purposes. The PMO was also assigned responsibility to coordinate industry peer reviews that were engaged to implement agency process improvements for project delivery. The PMO has served very well in these capacities and has served as the bridge across departments agency-wide to facilitate collaboration. The PMO office is involved with projects much earlier than historically possible as a means to maintain continuity and expedite project delivery. This early involvement with the project team facilitates communication of potential risks and issues that may impact project delivery and provides potential risk mitigation strategies.

The PMO, as authorized by the Board, has identified areas for increased value proposition related to updating project management systems to aid in oversight and reporting. Key benefits identified include a centralized repository for project information, web-based data available for both internal and external stakeholders for enhanced communication, improved data accuracy, version control and auditing, automated project cost information, electronic reporting, and integration to other systems.

The PMIS system that has been implemented realizes staff efficiency savings related to eliminating redundancy via a central data repository, reduction of labor intensive tasks that were accomplished in spreadsheets by providing accounting automation, and improving process methodologies. Standards such as common cost work breakdown structures, report templates, and project controls reports also enhanced staff efficiency. It takes less time to use a pre-populated template than create a brand new report. More timely management reports have been made available via the web for project stakeholder access. Standards have also helped ensure portability of staff from project to project with less disruption and shorter learning curve. The end result is more proactive communication of project issues and risks along with identification of potential risk mitigation plans.

The PMO delivered a two-day project manager training program that highlighted key processes within Metro and provided procedural guidance related to institutional policies and procedures. The PMO added value by proactively training managers in transit best practices including institutional policies and reporting requirements mandated at Metro. The training program was especially important related to staff growth where new managers did not have the organizational knowledge base. The value proposition for training is better trained managers, skilled in Metro practices, and policies that result in projects delivered within organizational expectations. Better-managed projects equates to greater cost and schedule savings and reduction of risk to the agency. Another key benefit is that better managed projects result in
improved stakeholder satisfaction. Stakeholder satisfaction is important as Metro is funded by taxpayers where transparency and accountability are necessary.

Lessons Learned

Implementation of the Metro PMO has experienced both successes and challenges. One key success was establishment of project controls as an autonomous organizational function. Project control is thriving and very well accepted as a key business function. This organizational change promoted reporting project issues and risks earlier in the project lifecycle. Program control is a new function being adopted. Some lessons learned from the beginning of implementation include communicating with executive management and establish clear expectations. This is a necessary step in formulating requirements and most importantly to obtain executive buy-in as primary sponsor for the change. Clear objectives with executive buyin are required and measurable goals are needed to evaluate success rates. Established success criteria are required so stakeholders understand what such accomplishments will look like when the implementation is complete. In Metro's PMO's case, expectations were not clear across all of the newly identified functions and staffing levels had not aligned with potential requirements. One position was granted to perform all tasks assigned for program control. This impacted enterprise-wide program control activities and delayed implementation. Institutional challenges were experienced related to justifying the difference between program versus project control functions compared to historically performed tasks.

Another lesson learned includes the importance of institutional standards related to tracking and reporting costs on the portfolio level. Metro program control standards related to portfolio reporting along with a standard work breakdown structure (WBS) for compiling costs did not exist. Projects reported individually without portfolio level standards. Lack of standards impacted identification of tangible goals and metrics for measurement. Portfolio reports were challenging due to differing cost data structures that could not readily be mapped together. Standard report formats did not exist. Every project’s monthly report varied slightly. Developing template formats took time to obtain buy-in of project participants.

As with any enterprise change initiative, change management strategies are necessary for successful implementation. Department funding limitations did not provide for change management support and this impacted delivery of visible products and services. Implementation has been phased as annual funds become available and rolling out each new program control function on a piecemeal basis. A lengthy implementation process has created a level of confusion among systems users making buy-in more difficult to obtain.

Conclusion

Metro has wisely implemented a Program Management Office (PMO) to assist in the delivery of the largest transportation capital program in the United States. Successful mega program delivery requires new strategies and adherence to project and program management policies. Great public transit programs are delivered with great expectations including successful delivery, accountability, and a transparent reporting system. The newly formed PMO delivers upon expectations by providing both project and program support with portfolio management, project management standards and training, and process improve-
ments. Project and performance management tools were designed to facilitate timely reporting and performance management metrics. Metro’s PMO and executives remain committed to facilitating process improvements to deliver the best possible results for the Los Angeles County taxpayers.

References
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Business failures among Small and Medium sized construction companies’ in Abuja, Nigeria

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ABSTRACT

Purpose of this paper

Business failures are risks that exist in all the various types of industries. The Nigerian construction industry has experienced a high incidence of Small and Medium business failure which has impacted negatively on the local construction market environment. The main purpose of this paper is to explore the factors associated with Small and Medium Enterprise construction (SMEs) company failures in the context of the Nigerian construction industry.

Design/methodology/approach

The study employed quantitative research approach using a well-structured questionnaire to elicit information from a purposive sample of 50 construction SMEs registered with Federal Housing Authority, Abuja.

Findings and value

The study results indicate that the main causes of business failure are lack of access to capital and undervaluing of construction works, poor estimating practices, and lack of evaluation of project profit yearly, and dealing with high magnitude of project. The study further categorized the causes of the failure under five main headings: lack of managerial experience; poor business strategy; poor project management; poor organisational administration, and poor coordination; finally presents strategies to assist companies survive.

Research limitations/implications

The study has some limitations which future researches need to eliminate. The study relied on the
use of cross-sectional data both from questionnaire survey of 50 SMEs in Abuja.

**Practical implications**

The results of the study present here will be a huge advantage to owners as well as managers of SMEs construction organisations in growing their businesses and enhancing their chance of survival. It will inform SMEs of the need to put into considerations political and business environment risk in their estimate and the need to improve their managerial and financial abilities in order to tackle the challenges.

**Originality/value of paper**

The results presented in this paper have important implications for the entrepreneurs who are contemplating starting a business in the construction industry and it also provides a clear signal of the potential business risk factors in doing construction business.

**Conclusions:**

The study concludes that the main causes of SMEs failures are political and financial factors as well as lack of managerial ability which have largely prevented them from breaking even.

**Keywords:** Business Failure, construction industry, Nigeria, SMEs Contractors,

**1.0 Introduction**

The construction industry has been reported to be a major and an important contributor in the economic growth of any nation. The industry significantly plays a prominent role as huge employer of people; and it provides abundance economic opportunities for SMEs (Small and medium sized enterprises) within the sector to grow; with its resultant output having a long time impact by providing abundant economic opportunities for their stakeholders (Van Wyk, 2003; Bowen et al., 2007). According to the National Bureau of Statistics (NBS) and Small and Medium Enterprises Development Agency of Nigeria (SMEDAN) (2012), in 2010 the contributions of SMEs to the country's economic growth in terms of investment in building and other construction related business is around 11% of the Nigeria's Gross Domestic Product (GDP). In spite of these contributions by the SMEs, their failure is very disturbing. Although business failure exists in all industries, but it is more pronounced within the construction industry where companies are prone to bankruptcy as a result of the hypercompetitive and fragmented nature of the industry, which is orchestrated by lack of entry barrier, high uncertainty and risk involved in the process (Wong and Ng, 2010).

The goal of every business is continuous survival in all circumstances. Gyadu-Asiedu (2009) opined that a poor business performance remain one of the problems confronting construction industry. Care should be taken by Contractors to take into proper cognisance factors that will affect their survival positively (Donkor, 2011). The studies of business failure have generated high interest with studies carried out by Arditi, Koksal and Kate (2000), Koksal and Arditi (2004), Kangari (1988)
and Russell and Zhai (1996). These authors explored causes of business failures, others developed prediction models and how organisation can manage their resources and competence in achieving good and competitive results. According to David and Eyo (2013), the occurrence of corporate failure in Nigeria is not well researched into apart from that which concerns the banking industry. But the fact is that Nigeria has been hit with a high occurrence of Small and Medium business failure which has impacted negatively on the local surroundings. However, researches concerning this class of business have not been extensively published. In view of the interest and attention been created on business failure, review of literature on construction firms shows paucity of research on business failure of construction firms in Nigeria. According to Arditi et al. (2000), data or reports on business failure offers the much needed assistance to construction entrepreneurs who are considering starting a business. It provides a clear indication of the likely risk factors operators in the industry may encounter as well as required experience for the professionals who are to manage the inherent risks.

Premise on this, the research aimed at exploring the cause of business failure of SMEs contractors in the Nigerian Construction industry context. This study will be presented as follows: a literature review on business failure and brief definition of SMEs will be presented in the next section, to be followed by the methodology of the study. The data for the study, its analysis, results and discussion will be presented. Finally, conclusion based on the findings will be presented after a discussion of the factors that cause business failures in the construction industry.

2.0 Literature review on business failure

Business failures have been researched into more at the project level compared to organisational level (Arditi et al., 2000). Kangari (1988) established a process system for classifying construction companies at the risk of failure. Abidali and Harris (1995) found that lack of engineering expertise, lack of robust financial director, insufficient cash flow plan, poor budgetary control system and unreliable bidding system contributed to company failure. Davidson and Maguine (2003) identified causes of construction contractors failure as growing too fast, obtaining contract in a new environmental locations, intense increase in single contract, procurement of new types of work, increase in number of workers, insufficient capitalization, poor appraising and job costing, poor accounting system and bad cash flow. Arditi, Koksal and Kate (2000) credited business failures to the following factors: human/organisational funds problems of adjustment to market condition, budgetary issues, macro economies issues and normal factors. According to Argenti (1986), the main sources of business failure are lack of fund, poor estimation, lack of control, lack of guidance, government guideline, vocational instability and fraud. Schaufelberger (2003) carried out studies of business failure at the level of subcontractor and discovered that the main causes of subcontractors business failure were inadequate capital/unnecessary debt, lack of managerial development, lack of early cautionary measures, increase in project magnitude, poor billing procedures, failure to appraise project profitability, lack of understanding within new geographical zones and poor use of accounting systems. Osama (1996) presented a study of the factors that contribute to the failure of construction contractors in Saudi Arabia and found that the most important factors were: difficulty in securing work, poor decision, and lack of knowledge in the firm’s line of work, problem with cash flow, lack of executive knowledge and low profit margins. Enshassi, Al-Hallaq,
and Mohammed (2006) researched into factors regarding business failure of contractors in developing countries. The results showed that the primary causes of business failure are delay in collecting debt from clients, boundary shutdown, substantial reliance on bank loans and payment of great interest on these loans, lack of capital, absence of industry guidelines, low profit brim due to high competition, awarding contracts by clients to the lowest bidders, and lack of knowledge in contract administration. Study carried out by Donkor (2011) on determinant of business failure revealed that abandonment of contracts of previous administration, inability to collect debts from new government officials, financial demand from political office holder, unwillingness in payment of interest on delayed payments etc. were the leading factors. This is evident in the number of companies that have been liquidated or become insolvent in the recent years with many being dormant and unproductive in the industry (Van Wyk, 2003; Thwala and Mvubu, 2008; Martin and Root, 2012). In fact, Van Wyk (2003) in a research conducted within the South African construction industry, suggested that few of the reasons for the failure of SMEs are due to lack of profitability in contracting, poor management and management expertise and chief among these are the metric of measuring performance which focused mainly on financial measures. Baard and van den Berg (2004) affirmed further that the origin of the failures could be traced to internal factors such as managerial incompetence, a lack of managerial experience, inadequate planning and poor financial control. The failure of the industry was acknowledged by Rwelamila et al. (2000), that asserted that most construction industry in the developing countries especially in Africa are vulnerable to accepting various techniques that tend towards development without considering local factors and country specific cultural issues in project management which have resulted into unpredictable outcomes.

3.0 Definition of SMEs

SMEs within this context mean small and medium-sized construction enterprises. Hudson (2001) asserted that SMEs are pretty difficult to define due to many factors involved and the incongruence that characterised their nature. There are myriad of definitions or what constitute SMEs (Deros et al., 2006; Fathian et al., 2008). Different countries have different definition for what SMEs represent (Hudson, 2001; Wu, 2009; Thassanabanjong et al., 2009; Mirbargkar, 2009) many adopt annual turnover, number of employees or asset to define size for classification of firms. The incongruities was as a result of the source where many of these definitions come from, mostly they are being defined based on Acts or for legal purposes; for example, United States Census Bureau (2008) that stated that small companies are those having not more than 500 employees on their payroll, medium companies consist of employees in the range of 500 to 2499 while large companies are those having more than 2500 employees. Australian Bureau of Statistics (ABS, 2001) defined small businesses to be inclusive of sole proprietorships and partnerships without employees, businesses having more than five employees are referred to as micro-businesses and other businesses employing five or more people but less than 20 people, whereas medium-sized businesses are defined as those employing people not more than 199 (ABS, 2001). SME Corporation of Malaysia cited in Rose et al. (2010) defined SME as a company with full time employees between 5 to 150 and annual sales turnover between RM251k to RM25 million. However, many criticisms have greeted these forms of classification of firms; this was as a result of difficulties involved in making comparisons when different units of measurement are being used in classifying companies (Hudson, 2001). Within the context of this study which focuses on Nigeria, where working capital, number of employees and
annual turnover were used in classifying companies. SMEs can therefore be defined as companies having full-time equivalent of paid employees ranging from 11 to 200 workers or whose working capital is between N100-300 Million or whose turnover is between N10-20 Million annually.

4.0 RESEARCH METHODS

This study was conducted using quantitative method. This approach was used through a questionnaire survey in an attempt to generate required information and identify array of causes of business failures from the sample population. The factors were identified through extensive review of existing literature that revealed a myriad of causes of business failures in the construction industry (Arditi et al. 2000; Enshassi et al., 2006; Ibn-Homaid and Tijani, 2015). This led to the identification of 48 factors that may lead to contractors’ business failure and 22 strategies for minimising failures which were used in developing the questionnaire. The questionnaire was divided into three parts: the first part was used to obtain background information which centred on the general particulars of the respondent’s organisation, and other information such as the years of experience of the respondent, the respondent’s position within the organisation. The second part requested the participants to rate the causes of business failure based on their experience, while the last part delved into likely strategies that may be employed by SMEs in mitigating the occurrence of business failure. To ensure content validity, the questionnaire was reviewed by three senior colleagues and experts in research methodology and questionnaire design. Amendments were then made to the questionnaire as suggested by the experts before it was finally self-administered on the field. As a result of the difficulties in obtaining a comprehensive list of SMEs construction companies in Abuja the study area, the list of those SMEs that registered with Federal Housing Authority (FHA) was obtained with their addresses and telephone numbers. Telephone calls were made to these companies to confirm the addresses, intimated them of our intention and to ascertain who to meet to find out the potential respondent within the organisation based on the structure of their companies. The interest of CEOs/senior managers in participating in the study was arose through personal interactions and by confiding in them that the responses were for academic purpose only. This assisted in administering the questionnaires to the appropriate person. The questionnaire was self-administered to a total of 50 SMEs construction companies identified and verified on the list obtained from FHA requesting their contributions in rating the identified 48 factors in terms of severity in causing business failure using an ordinal scale (see Enshassi et al., 2006). The Likert scale used are 1 = very low influence, 2 = low influence, 3 = moderate influence, 4 = high influence, and 5 = very high influence. A total of 50 questionnaires were self-administered to the senior managers or CEOs where applicable as the major respondents for the study, because it is assumed that they are likely to have more information and knowledge about the difficulty their respective companies encounter in the course of operating within construction industry that may lead to distress. After series of calls and visits, a total of 50 completed questionnaires were retrieved representing a very high response rate of 100%. The data were analysed using both descriptive and inferential statistics.

5.0 RESULTS AND DISCUSSION

Table 1 provides the summary of the background information of the respondent’s organisation. The results in Table 1 indicate that 56% of the respondent are Sole proprietorship which is typical of SMEs.
firms, while Partnership and Private Liability Company had 26% and 18%. None of the company under consideration is Public Liability Company. Table 1 also shows that 14% of the respondents have less than 5 years working experience, 36% have between 6 to 10 years, 36% have between 11 to 15 years and 14% have between 16 to 20 years. This extensive working knowledge would make the results more reliable. The result in Table 1 shows that 56% of the contractors have less than 71 numbers of permanent workers, a development which shows that such contractors are not growing and their ability to take charge of infrastructural development of the country will be difficult.

Table 1: Background information

<table>
<thead>
<tr>
<th>Business Registration Category</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sole Proprietorship</td>
<td>28</td>
<td>56</td>
</tr>
<tr>
<td>Partnership</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>Private liability company</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Public liability company</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year your firm has been in business</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5 years</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>11 to 15 years</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>16 to 20 years</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>&gt;20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of employee in your company</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;30</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>11-70</td>
<td>19</td>
<td>38</td>
</tr>
<tr>
<td>71-200</td>
<td>22</td>
<td>44</td>
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<td>over 200</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 2 and 3 present the means and standard deviations as well as ranking for all variables. The items used in the questionnaire required respondents to rate on a 5 point Likert scale from 1 to 5. The study mean score of each of the variables was determined to ascertain the most severe factors that often result into SMEs distress. The mean statistics was employed in analysing the perceptions of the respondents that could range between e.g. very high influence 5 points, very low influence 1 point. In exploring the variables identified in the survey, the study first used analytical descriptive statistics to denote the data in terms of the mode, median and mean, as well as the standard deviation. These measures were employed to generate a methodical understanding of the nature of data and give a summary of the variables used.
Table 2 shows the mean value of and rank for all business failure variables in a descending order. The descriptive results show that lack of access to capital and undervaluing of construction works are the top two most severe factors based on ranking that may lead to business failure. These are closely followed by poor estimating practices, lack of evaluation of project profit yearly, and dealing with high magnitude of project complete the list of the most five important causes of business failure for all the business variables. These findings are closely related to the previous findings in literature (e.g. Schaufelberger, 2003; Van Wyk 2003), who identified lack of capital and of profitability in contracting as causes of business distress. The lowest ranked business failure factors were lack of using project management techniques, owner’s involvement in the construction phase, replacement of key successful personnel.

Table 2: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean Statistic</th>
<th>Ranking</th>
<th>Std. Error</th>
<th>Std. Deviation</th>
<th>Alpha without item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of access to capital</td>
<td>4.20</td>
<td>1</td>
<td>.13</td>
<td>.88</td>
<td>.91</td>
</tr>
<tr>
<td>Under-valuing of work done</td>
<td>4.14</td>
<td>2</td>
<td>.11</td>
<td>.76</td>
<td>.92</td>
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Table 2 cont’d: Descriptive Statistics

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<td>Lack of well-structured training and re-training programme</td>
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<td>Delay in collecting debt from new political heads</td>
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Table 3 presents the mean value of the business strategies that can be used by companies to mitigate business failures and rank for all the strategy variables in a descending order. The descriptive results indicate that easy access to capital, control of overheads and recurrent expenditure, effective purchase system, flexible interest rate for lending purposes, and undervaluing of construction works are the top five strategies SMEs could employ to overcome business distress. The least ranked strategy for reducing business failure factors were compensation and bonuses packages, ensuring regular and accurate valuation of work, and separation of business activities from family matters. The Table also shows the Cronbach’s alpha that was used to examine the internal consistency of the factors identified in literature and to assess whether co-variation among the variables measuring the business failure (Oyewobi, 2014). However, previous researchers (such as Sanders, 2003) have suggested that a minimum acceptable Cronbach’s alpha value is 0.7, and Nandakumar (2008) stated that 0.6 could be considered acceptable in exploratory research.
Unlike previous study such as Arditi et al. (2000) and Enshassi et al. (2006), where the factors causing business failure were grouped before the analysis, this study explore the variables identified using factor analysis. The study therefore use exploratory factor analysis in bringing together underlying variables that are interrelated, thereby generating a factor structure through an inductive approach. This was used to examine the appropriateness of the data for further analysis and also to indicate which variables are highly correlated with one another, thereby forming sets of variables that are known to relate to each group. The results of the factor analysis are presented in Table 4 and 5. However, the overall, Cronbach’s alpha statistics are well above the 0.60 to 0.70 threshold range and the Kaiser–Meyer–Olkin (KMO) statistic and Bartlett test for sphericity confirm the adequacy of the sample for factor analysis. The analysis in Table 4 showed five factors were clustered under causes of business failure. The five components include: lack of managerial experience; poor business strategy; poor project management; poor organisational administration, and poor coordination.

### Table 3: Descriptive Statistics

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<thead>
<tr>
<th>Variables</th>
<th>Statistic</th>
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<th>Error</th>
<th>Deviation</th>
<th>item</th>
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<td>Separation of business activities from family matters</td>
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</table>

**Exploratory factor analysis**

Unlike previous study such as Arditi et al. (2000) and Enshassi et al. (2006), where the factors causing business failure were grouped before the analysis, this study explore the variables identified using factor analysis. The study therefore use exploratory factor analysis in bringing together underlying variables that are interrelated, thereby generating a factor structure through an inductive approach. This was used to examine the appropriateness of the data for further analysis and also to indicate which variables are highly correlated with one another, thereby forming sets of variables that are known to relate to each group. The results of the factor analysis are presented in Table 4 and 5. However, the overall, Cronbach’s alpha statistics are well above the 0.60 to 0.70 threshold range and the Kaiser–Meyer–Olkin (KMO) statistic and Bartlett test for sphericity confirm the adequacy of the sample for factor analysis. The analysis in Table 4 showed five factors were clustered under causes of business failure. The five components include: lack of managerial experience; poor business strategy; poor project management; poor organisational administration, and poor coordination.
Lack of managerial experience

This is one of the main causes of construction business failure by the SMEs. SMEs with inexperienced owner or management that consists of personnel with little knowledge about construction work may have the business closed down due poor decisions as a result of poor managerial skill. This finding underscores the previous study by Osama (1997) in the context of Saudi Arabia, who examined the factors contributing to the failure of construction contractors and found that the most prominent cause of failures include lack of experience in the company’s line of business, difficulty with cash flow and poor managerial experience. This result is supported by the assertion of Schaufelberger (2003) who assessed the causes of business failure at the level of subcontractor and discovered that the main causes of subcontractor’s business failure were lack of managerial development and inadequate capital/unnecessary debt among others. Similarly, Kivrak and Arslan (2008) reported on the critical factors causing failure of SMEs construction companies in Turkey. The study revealed that lack of business experience and country’s economic conditions as the most influential factors to company failure. Hence, in engaging in any business, most especially construction, experienced people in that field are more desirable to ensure continuous improvement and survival. These together explain more than approximately 15% of the variance.

Poor business strategy

Organisation or company that fails to have a comprehensive business plan will fail particularly in the construction business environment where there are lots of uncertainties in terms of securing jobs. Regular and continuous assessment of organisation is required by construction companies, this will assist in developing and implementing relevant business strategies that can sustain the business and guarantee continuous existence in the market niche (Ibn-Homaid and Tijani, 2015). Construction business environments are dynamic and may change with time, it is thus essential that strategy developed must be modified appropriately in order to sustain a dynamic sense of balance between the company and its environments (Ho, 2015). Many of the SMEs lack appropriate business strategy to withstand the business environment and as such experience low profit margin due to high competition and poor cash flow (Arditi Koksal and Kale, 2000; Enshassi et al., 2006). According to Arditi et al. (2000), low profits and crunch cash flow are synonymous with the construction business, which is typified by one-off projects and hypercompetitive business environment due to the tendering procedure; this constitute a major source of failure to the SMEs (Davidson and Maguire, 2003). Poor business plan can lead to overexpansion which is capable of driving a company to greater risk investments with huge financial deficit, thus increasing company's chances of failure (Arditi et al., 2000). Business strategy explains 14.18%

Poor project management

Projects require to be controlled from inception through to the completion stage. This can be achieved using any of the numerous project management techniques. Ibn-Homaid and Tijani (2015) reported that the Surety Information Office (SIO) identified six warning indications that show that a construction company may be in distress. Prominent amongst these factors is poor project management. This is also emphasised by Enshassi et al. (2006) who argued that more than half of business fail-
ure in construction industry are due to unrealistic project margin. Project management techniques are considered ever-changing techniques, similar to those in nature, which depict they change over time and are hard to predict (Ahmadi and Golabchi, 2013). No matter how big or small a company is, it requires a good and effective management to ensure that the company objectives and goals are achieved. SMEs construction companies should therefore adopt management techniques such as risk management and the rest for project implementations. However, the majority of these SMEs contractors that are functioning within the Nigerian construction industry are small-scale outfits with fair level of ignorance in research and development breakthroughs that can improve their output and efficiency both in terms of technical know-how (application of technology) and management techniques. Their inability to employ qualified and experienced personnel coupled with lack of ploughing back profit have created business setbacks for them. This component explains 8.91% of the variations in the business failure.

**Poor organisational administration**

The following factors were categorised under the heading- Poor organisational administration. The clustered variables include delay and improper claim submission process; neglect of issues/action that can cause the company losses; bad company organisation; lack of employee benefit and compensation; delay in collecting bills/payment; weak construction industry regulations; change in government policies. These variables are capable of affecting business failure, they collectively explain 7.56% of the variance.

**Poor coordination**

The last factor is named poor coordination. The variables that explain these factor include; poor communication system; assigning of unqualified/incompetent project leader at the site; lack of evaluation of project profit yearly; shrinkage in construction activities; and delay in collecting debt from new political heads. This finding is in line with Josephson, Larsson and Li (2002), that emphasised that poor coordination may likely result into failure though at project level. Meanwhile the industry where these SMEs operate is project based and project success according to Faniran, Love and Li(1999) is hinged upon the effectiveness of the main contractor’s (and their subcontractors and suppliers) construction planning efforts. These together explain 7.08% of the variance.
Table 4: Factor analysis of causes of business failure

<table>
<thead>
<tr>
<th>Variable</th>
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<th>FAC2</th>
<th>FAC3</th>
<th>Communalities</th>
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</tr>
<tr>
<td>Financial demands by political heads</td>
<td></td>
<td>.849</td>
<td></td>
<td>.813</td>
</tr>
<tr>
<td>High cost of construction material</td>
<td></td>
<td>.857</td>
<td></td>
<td>.800</td>
</tr>
<tr>
<td><strong>Poor managerial experience</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of experience in the line of work</td>
<td></td>
<td>.764</td>
<td></td>
<td>.723</td>
</tr>
<tr>
<td>Bad decisions in formulating and regulating company policies</td>
<td></td>
<td>.592</td>
<td></td>
<td>.628</td>
</tr>
<tr>
<td>Sudden death of company owner</td>
<td></td>
<td>.643</td>
<td></td>
<td>.587</td>
</tr>
<tr>
<td>Inappropriate procurement practices</td>
<td></td>
<td>.696</td>
<td></td>
<td>.559</td>
</tr>
<tr>
<td>Owners absence from the company</td>
<td></td>
<td>.815</td>
<td></td>
<td>.762</td>
</tr>
<tr>
<td>Non completion of construction work on schedule</td>
<td></td>
<td>.749</td>
<td></td>
<td>.621</td>
</tr>
<tr>
<td>Lack of managerial development and maturity as the company grows</td>
<td></td>
<td>.662</td>
<td></td>
<td>.590</td>
</tr>
<tr>
<td>Dealing with increase in the size of projects</td>
<td></td>
<td>.532</td>
<td></td>
<td>.527</td>
</tr>
<tr>
<td><strong>Initial Eigenvalues</strong></td>
<td>11.90</td>
<td>6.80</td>
<td>4.278</td>
<td></td>
</tr>
<tr>
<td><strong>% of Variance</strong></td>
<td>24.79</td>
<td>14.18</td>
<td>8.91</td>
<td></td>
</tr>
<tr>
<td><strong>Cumulative %</strong></td>
<td>24.79</td>
<td>38.96</td>
<td>47.87</td>
<td></td>
</tr>
</tbody>
</table>
Table 4 cont’d: Factor analysis of causes of business failure

<table>
<thead>
<tr>
<th>Variable</th>
<th>FAC4</th>
<th>FAC5</th>
<th>Communalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor organisational administration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay and improper claim submission process</td>
<td>.558</td>
<td>.467</td>
<td></td>
</tr>
<tr>
<td>Neglect of issues/action that can cause the company losses</td>
<td>.635</td>
<td>.766</td>
<td></td>
</tr>
<tr>
<td>Bad company organisation</td>
<td>.738</td>
<td>.719</td>
<td></td>
</tr>
<tr>
<td>Lack of employee benefit and compensation</td>
<td>.848</td>
<td>.828</td>
<td></td>
</tr>
<tr>
<td>Delay in collecting bills/payment</td>
<td>.738</td>
<td>.719</td>
<td></td>
</tr>
<tr>
<td>Weak construction industry regulations</td>
<td>.738</td>
<td>.719</td>
<td></td>
</tr>
<tr>
<td>Change in government policies</td>
<td>.848</td>
<td>.828</td>
<td></td>
</tr>
<tr>
<td>Poor coordination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor communication system</td>
<td>.867</td>
<td>.829</td>
<td></td>
</tr>
<tr>
<td>Assigning of unqualified/incompetent project leader at the site</td>
<td>.770</td>
<td>.854</td>
<td></td>
</tr>
<tr>
<td>Lack of evaluation of project profit yearly</td>
<td>.582</td>
<td>.601</td>
<td></td>
</tr>
<tr>
<td>Shrinkage in construction activities</td>
<td>.807</td>
<td>.829</td>
<td></td>
</tr>
<tr>
<td>Delay in collecting debt from new political heads</td>
<td>.770</td>
<td>.854</td>
<td></td>
</tr>
<tr>
<td>Initial Eigenvalues</td>
<td>3.63</td>
<td>3.40</td>
<td></td>
</tr>
<tr>
<td>% of Variance</td>
<td>7.56</td>
<td>7.08</td>
<td></td>
</tr>
<tr>
<td>Cumulative %</td>
<td>55.44</td>
<td>62.51</td>
<td></td>
</tr>
</tbody>
</table>

Cronbach alpha of the whole scale: 0.93
KMO: 0.87.
Barlett test: Χ²=427.240 gl. 105 sig. 0.000

Strategies to minimise business failure

The study employed the PCA approach adopting varimax rotation to extract possible factors, and Kaiser’s criterion (i.e. Eigenvalue-greater-than-one) to ascertain which factors to retain from the analysis. Table 5 indicates three factors having initial Eigenvalues greater than 1 which were extracted from the variables used in determining the strategy SMEs can adopt in guiding against business distress. The Table shows that the first component is capable of explaining approximately 3% of the variation, the second extracted component explains 13%, while the last factor extracted explains 36% of the variance. The three components combine to explain 47% of the total variance. Each of the factors had at least four variables loaded on them after being rotated using varimax method. The rotation was executed in 25 iterations to eliminate multidimensional variables and ensure that the variables were loaded onto only one factor (Field, 2013). The clustered factors are: Financial issues, management issues and human/organisational issues.

Financial issues: the variables that converge to explain these are, proper financial practices, effective cash flow practices, proper material control systems, good Management team, adequate balance of assets and Liabilities. This strategy becomes necessary as most of contracting organisation experience major problems in cash flow, capital and harsh competition in a very difficult situation.
Enshassi et al. (2006) further stated that it is general knowledge that most SMEs have no dedicated accounting department that make public the company's financial reports on a regular basis (they are not obligated by law in Nigeria if they are quoted on the Stock Exchange) and thus, effective monitoring of financial ratios become rather difficult. This is underscored by Ibn-Hamoid and Tijani (2015), who after review of literature on construction business failure, posited that the major factor causing business failure is financial management. Wong and Ng (2010) therefore asserted that there is need for construction companies to assess their financial performance on a regular basis so that timely and appropriate strategies can be instituted to maintain their survival in the construction business.

Management issues: six variables clustered to explain the variance and these variables include: easy access to capital; transparent and effective tendering systems, good and proper record keeping procedure, effective purchase system, adequate capital structure and business expansion at gradual speed. Yin (2006) attributed lack of access to capital to finance the construction works by the contractors as one of the factors of the failure. Enshassi et al. (2006) also contended that taking more projects by contractors beyond their capability is a recipe for failure. To mitigate these problems and ensure survival of companies in the turbulent business environment, there is the need for effective management. We argue here that management of financial related issues and other processes will help organisations overcome factors that may lead to distress and stunted growth.

Human/organisational issues: four variables including compensation and bonuses packages, training programmes for contractors, separation of business activities from family matters, ensuring regular and accurate valuation of work combine to explain approximately 36% of the variance. This implies that company's human resources and managerial capabilities are the main factors that ensure sustainable competitive advantage and hence profitability (Spanos, Zaralis and Loukas, 2004). According to Cheah and Garvin (2004), the essence of human resources is to offer an efficient organisational system that will lead to recruiting, training, mobilizing and managing the human assets of an organization to systematically carry out business operations and new business enterprises. The nature of the construction industry which is project-based requires a number of individuals to get work done.
Table 5: Strategies for survival of SMEs contractors business

<table>
<thead>
<tr>
<th>Variable</th>
<th>FAC1</th>
<th>FAC2</th>
<th>FAC3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial issues</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper Financial practices</td>
<td>.558</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective cash flow practices</td>
<td>.796</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper material control systems</td>
<td>.829</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good Management team</td>
<td>.600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adequate balance of assets and Liabilities</td>
<td>.829</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Management issues</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy access to capital</td>
<td></td>
<td>.624</td>
<td></td>
</tr>
<tr>
<td>Transparent and effective tendering systems</td>
<td></td>
<td>.831</td>
<td></td>
</tr>
<tr>
<td>Good and proper record keeping procedure</td>
<td></td>
<td>.511</td>
<td></td>
</tr>
<tr>
<td>Effective Purchase system</td>
<td></td>
<td>.631</td>
<td></td>
</tr>
<tr>
<td>Adequate Capital Structure</td>
<td></td>
<td>.516</td>
<td></td>
</tr>
<tr>
<td>Business expansion at gradual speed</td>
<td></td>
<td>.831</td>
<td></td>
</tr>
<tr>
<td><strong>Human/organizational issue</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compensation and bonuses packages</td>
<td></td>
<td>.725</td>
<td></td>
</tr>
<tr>
<td>Training programmes for contractors</td>
<td></td>
<td>.613</td>
<td></td>
</tr>
<tr>
<td>Separation of business activities from family matters</td>
<td></td>
<td>.864</td>
<td></td>
</tr>
<tr>
<td>Ensuring regular and accurate valuation of work</td>
<td></td>
<td>.776</td>
<td></td>
</tr>
<tr>
<td>Initial Eigenvalues</td>
<td>5.119</td>
<td>23.267</td>
<td>23.267</td>
</tr>
<tr>
<td>% of Variance</td>
<td>2.929</td>
<td>13.316</td>
<td>36.583</td>
</tr>
<tr>
<td>Cumulative %</td>
<td>2.382</td>
<td>10.829</td>
<td>47.411</td>
</tr>
</tbody>
</table>

Cronbach alpha of the whole scale: 0.67
KMO and Bartlett's Test                                                     .626
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.                           415.079
Bartlett's Test of Sphericity                                              df  91
                 Sig. .000

6.0 Conclusion

Construction business failures are not only extremely disruptive to the industry but it may pose a threat to the economy of the nation. Business failure reports provide the much needed assistance to businesspersons who are thinking to start a construction business, because it makes known the likely threat to company's survival in the industry. The main objective of this paper is to explore the factors that have the potential to cause business failure of SMEs in the Nigerian construction industry and to determine their level of severity from SME's perspective and possibly group them under different headings. The identified variables by the study were categorised under five main heading: lack of managerial experience; poor business strategy; poor project management; poor organisational administration, and poor coordination, while strategies clustered into three factors. The most important causes of business failure as indicated by the SMEs are lack of access to capital and undervaluing of construction works, poor estimating practices, and lack of evaluation of project profit yearly and dealing with high magnitude of project. Therefore, the strategies that SMEs can employ to neutralize the potential causes of business failure to ensure survival in the industry
include efficient financial management, effective management strategies and human/organisational resources management.

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Eindhoven for the Award of Doctorate Degree.


Rwelamila, P. D., Talukhaba, A. A and Ngowi, A. B (2000). Project procurement systems in


A Learning Curve Investigation: Multiple Phase

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ABSTRACT

Wright’s log-linear learning curve remains the most popular of all the available ones in the literature. This is due to its simplicity and its ability to fit most cases. Despite its popularity it is criticized because as the cumulative production goes to infinity the result of the model goes to zero, which is impossible. In this paper it is proposed that wright’s log-linear learning curve model can be used as having two or more legs and for each leg different learning rates can be applied. This means learning percent can change at some certain points of the curve. By doing so the model can fit the data more accurately. Although a few similar implications can be found in the literature, it is not given the enough importance and there is no well-built model in the literature yet. A few questions arise for the proposed model for further research: how many legs should be considered and in which type of production types, at which points should the legs be broken and what should be the learning rate in different legs. A real data set is analysed in this paper as an example.

Keywords: Learning curve, multiple legs, multiple phase.

1. INTRODUCTION

A learning curve is a mathematical description of workers’ performance in repetitive tasks (Wright, 1936). Learning (or experience) curves assume that performance (output) improves as a task is repetitively performed, which is attributed to experience that is accumulated by the individual or group performing the task. (Grosse et al., 2015)

LCs were empirically developed by Wright (1936) after observing how assembly costs of airplanes decreased as repetitions were performed. Such reduction followed a constant rate as the number of assembled airplanes doubled, giving rise to a rule-of thumb named “80% learning curve” that was widely applied in the aeronautical industry of the time. According to that rule cumulative assembly costs are
reduced on average by 20% as the number of units is duplicated (Anzanello and Fogliatto, 2011). Factors contributing to this improved performance include more effective use of tools and machines, increased familiarity with operation tasks and work environment, and enhanced management efficiency (Salameh et al., 1993). Reliable prediction of task times in such environments is important for several reasons including improved estimates for task completion time, planning for appropriate levels of resources needed for task completion, pricing, and for setting meaningful standards against which comparisons can be made (Jaber and Kher, 2001).

Wright’s log-linear learning curve remains the most popular of all the available ones in the literature. This is due to its simplicity and its ability to fit most cases. Despite its popularity it is criticized because as the cumulative production goes to infinity the result of the model goes to zero, which is impossible. Several models are developed to overcome this problem in the literature. De Jong (1957) proposed a model including a plateauing factor. Dar-El et al. (1995) proposed the dual-phase learning curve model (DPLCM) which takes into account the cognitive and motor elements of the learning process. In this paper it is proposed that wright’s log-linear learning curve model can be used as having two or more legs and for each leg different learning rates can be applied. This means learning percent can change at some certain points of the curve. By doing so the model can fit the data more accurately. Moreover the relationship between the first and the second production unit may be analysed specifically because of the FAI (first Article Inspection) concept in aerospace industries.

Grosse et al. (2015) have grouped the learning curve studies in the literature in three main groups as individual learning, group learning and organisational learning. The learning curve concept in this study is related with the group learning in built-to-print type production.

2. LC MODELS

The literature about the learning curve models starts with Wright (1936). Although many models are developed in the past, the most common learning curve models in the literature is summarised below and in table 1 (Grosse et al, 2015).

1. Wright’s Model (WLC), Wright (1936): Wright showed that as production unit doubles, the assembly costs of airplanes decrease by a learning factor.

2. Plateau Model (PM), Baloff (1971): Plateau added a constant to Wright’s formula, stating that there exists a minimum time for performing a task.

3. Stanford B Model (SBM), Carlson (1973): The Stanford B learning curve extends Wright’s learning curve by considering prior experience

4. De Jong’s model (DJM), De Jong (1957): This model adds the incompressible component in which the learning can not be applied. The factor “M” depends on the automatization of the process.

5. S-curve model (SCM), Nembhard and Uzumeri (2000): Name of the model comes from the S shape of the model no logarithmic scale. Model combines the characteristics of the Stanford B model and De Jong’s model.

6. Jaber–Glock Learning Curve Model (JGLCM), Jaber and Glock (2013): This model takes into account the fact that in most industrial tasks, both cognitive and motor learning occurs.
The learning curves briefly explained above are the most common ones in the literature and are all log-linear models. Beside these models there are many more models of learning which can be also in the form of exponential and hyperbolic models.

3. PROPOSED MODEL - MULTIPLE PHASE LEARNING CURVE

According to Wright’s log-linear learning curve, a single learning rate is applied in a model for different types of works. One of the main reasons it is criticized is that as the cumulative production goes to infinity the result of the model goes to zero, which is impossible. According to the “plateau learning curve model”, learning is flattened after a certain point of production. This is also not practical in real life because learning, although in a very little rate, is observed continuously. Also, the customer wants a continuous improvement for the production and asks for a related price discount. Such commercial issues force production people to make continuous improvements. In this case, Wright’s log-linear learning curve model can be used as having two or more legs and for each leg different learning rates can be applied. This means learning percent can change at some certain points of the curve. By doing so, the model can fit the data more accurately.
In this paper, a real life data is analysed in three legs. The data contains production hours for a labor intensive complex assembly type production of 715 units, which is shown as the blue lines in graph 1. Analysing the trend line of 715 units, a learning rate of 95% is calculated. This is in fact, the best line fitted log-linear curve. In the literature the learning rate for a similar type of production should be 85%. However there is no study about the end point of the learning stated in the literature. This is one of the future works related with this issue.

**Graph 1: Analysis of the Actual data**

![Graph 1: Analysis of the Actual data](image)

**Graph 2: Analysis of the Actual Data, first 150 Units**

![Graph 2: Analysis of the Actual Data, first 150 Units](image)
The first unit is produced in 795 hours. If we assume that the first unit will be produced in 795 hours and apply the learning rate of 85% as the literature suggests, the production hour for the 715th unit will be 170 hours (green line in Figure 1). However, according to the actual production hours we can see that 715th unit is 270 hours, which is very different from the estimation. In graph 2, it is obvious that the learning rate is changing at around 50th unit. With a further analysis it is seen that there is slight difference in the learning rate at around 150th unit.

Table 2: Analysis of the Actual Data with 3 legs

<table>
<thead>
<tr>
<th>Units (Leg)</th>
<th>Learning Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st leg</td>
<td>1 - 50</td>
</tr>
<tr>
<td>2nd leg</td>
<td>51 - 150</td>
</tr>
<tr>
<td>3rd leg</td>
<td>151 - 715</td>
</tr>
</tbody>
</table>

Actual data is divided into three legs and the learning percent of each leg is analysed separately. In table 2, the learning percent of each leg is stated.
Graph 3: Analysis of the Actual Data with 3 legs

The graphical analysis of the actual data as three legs can be seen in graph 3. Especially in leg 3, it is obvious that an estimation using the first unit of the actual data and the industry learning average 85%, which is represented by the green line, is not a good estimate of the actual data.

4. FINDINGS

The data of 715 units is analysed in three different methods as summarised in Table 3.

First method is “3-Legs” method, which can be generalised as “multiple legs” method and is the proposed method in this article. When analysing the data with this method, the data is divided into three legs and learning percent are calculated for each leg separately (Table 2). Supposing the production hour for the first unit is 795, if we use the learning percent in table 3 for three legs and estimate the production hours for 715 units, we come up with the red line in graphs. The average hours for three legs is summarised in Table 3.
Table 3: Summary of Analysing Models

<table>
<thead>
<tr>
<th>Actual Data</th>
<th>3-Legs (proposed model)</th>
<th>1-Leg (industry learning average)</th>
<th>1-Leg Trend Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st unit</td>
<td>795</td>
<td>795</td>
<td>429</td>
</tr>
<tr>
<td>Learning Percent</td>
<td>84%-98%-99%</td>
<td>85%</td>
<td>95%</td>
</tr>
<tr>
<td>1st leg (1-50) average</td>
<td>374</td>
<td>389</td>
<td>405</td>
</tr>
<tr>
<td>2nd leg (51-150) average</td>
<td>304</td>
<td>293</td>
<td>273</td>
</tr>
<tr>
<td>3rd leg (151-715) average</td>
<td>285</td>
<td>287</td>
<td>196</td>
</tr>
<tr>
<td>All (1-715) average</td>
<td>294</td>
<td>295</td>
<td>221</td>
</tr>
<tr>
<td>SSE</td>
<td>1574803</td>
<td>1861078</td>
<td>6309765</td>
</tr>
</tbody>
</table>

If making the same estimation for 715 units, assuming the first unit is 795, but using only one leg and the related industry average for the learning percent, which is 85%, the result is the green line in the graphs. The average is summarised in Table 3 in the column “1-Leg (industry learning average)".

The power trend line of the actual data, is the black line in the graphs. This refers to the “1-Leg Trend Line" column in Table 3, which has the first unit as 429 and a learning percent of 95%.

When comparing the different models, evaluation criteria can simply be taken as the sum of squared errors (SSE). As can be seen in Table 3, 3-Legs method has the smallest SSE. Also, analysing the averages of different legs can be helpful to get more insight about the different methods. For the first leg, the average of the “3-legs" model is the closest to the actual data average. For the second leg, the average of the “1-leg (industry learning average)" model is slightly better then the “3-legs" model. And finally for the third leg, the average of the “3-legs" model is the best one again. As also can be seen in graph 3, the best fit model is the “3-Legs (proposed model)" model. It would be a good estimation if the production unit is not more than 50 to use the 1-Leg with the industry learning percent. However this time, we would have a problem in the third leg, the average hour would be too low compared to the actual data. Finally if the power trend line is used for the estimation, the average for the first leg will be very low according to the actual data.

5. SUMMARY

A real data set of 715 production units is analysed and three different methods is compared with the actual data. As can be seen in table 3, the best fit model is 3-legs model, which uses the Wright's learning curve model with three legs. In the wright’s learning curve model, as the production quantity goes to infinity, the result of the model goes to zero. There are several learning curve models in the literature to overcome this problem. In this article this problem is solved by using multiple legs. By using multiple legs, estimated data fits better to the actual data.
6. FURTHER RESEARCH

3-legs model is in fact a special case of multiple-legs model. Further research can be made for questions like: How many legs should be used in different types of production?, What should be the length of each leg?, Determining the industry standards of learning percent for each leg.

REFERENCES


META-INTEGRATION
A methodology for integrating projects from the commissioning stage

Jefferson Guimarães
João Carlos Papadopoulos de Souza

ABSTRACT
This paper offers an approach to projects and megaprojects integration by analyzing the transitional stage between their full implementation and start-up and by observing that the relationship between projects and the context within which they are inserted may exceed the limit of their portions management. Knowing in advance the ideal sequence of deliveries and projects set requirements will prevent problems during the implementation stage and turbulences in contractual relationships, delays, additional costs and revenues postpones.

The method involves using a multidisciplinary team of experts to identify all the relationships among components in the design documentation, contractual requirements or execution plans as those non-described in the formal documentation. All relationships should be considered, including the least important ones.

Thus, the planner will identify the “knowledge gaps” of the non-explicit demands that are essential to system commissioning and operation and should be considered in the interfaces planning, such as well-trained operators, licenses and permits, ICT services, laboratory analysis, specialists availability etc.

However, knowing who and why demands, what is demanded, who and how provides is not enough, because it remains to be set when can be initiated each one of all preliminary stages of the start-up. The method builds on supplying all demands of the key player component, necessary for performing each stage of its commissioning and which one or more supporting player component shall provide through “streams and services”.

By applying the method, it is possible to know how to act in logical loops inside the original design concept and anticipate solutions, as well as support the decision between make or buy, transfer or take the risk and, above all, to plan the procurement packages for the best cash flow.

Our experience makes us believe that it should be valuable to run this method before setting the procurement plan. Truly, it should be an input for that.

The unavailability of an integrated team of specialists or the lack of sponsorship by managers, caused
mainly by the misunderstanding of the importance of a “too” early commissioning planning might be the key restrictions on this methodology.

The contracting strategy must meet the requirements found on the start-up sequence map for both the project and its context. The situation worsens in case of megaprojects, usually performed through multiple contracts. The gap between dates (milestones in schedules) will indicate threats to of each component start-up and to the set, higher costs and revenue postponement.

The meta-integration allows us to understand the impact of each of these gaps on the integrated schedule, since it allows reestablishing the system and its complexity by reordering parts by their required interactions.

The meta-integration increases the effectiveness in portfolio iterations and improves the progress report of each component, empowering risk management and strategic benefits tracking.

Keywords: meta-integration, schedule, costs, commissioning, complexity.

1 - INTRODUCTION

At first glance, the complexity brings us back to the paradox of the one and the multiple, which is presented as a tissue made from inseparably associated heterogeneous components (Morin, 1990). Complexity is not a problem itself. Complexity is an attribute that, if disregarded, may result in many problems.

In the context of project and megaprojects management, complexity is a natural attribute. Facing this true situation, apparently chaotic, is our challenge from the very early stages of planning.

It is the human being nature the need to understand what is in the surrounding, in order to do so he establishes processes for breaking down the study object, classifies and divides it, and ordains its parts. These principles reflect the archetype of simplicity, which imposes order in the universe and from it expels disorder. The keystone of this pragmatic thinking, necessary for scheduling environment, is known as the paradigm split-and-cut short, i.e., it separates what is attached, in search of clear and distinctive ideas, reduces and coordinates them in a structure that restores the complexity from the ordinary, as a philosophical thought that shapes the complexity from unpretentious observations.

The integration subject present in the PMBOK takes into account the project management knowledge areas and, in the ISO 21500, the integration subject considers matters related to a single project management. It seems to us that these two approaches are equivalent, relevant to a single project management, but it doesn’t meet our proposal: to build up a methodology for projects and megaprojects integration.

Due to the shared understanding of the word integration, and its meaning in project management, we will use a new term: meta-integration.

Meta, from Greek language: metá (besides through, change, transcendence or critical reflection on). Thus, meta-integration corresponds to a specific notion of integration, which starts from the transition
analysis that occurs between the implementation and operation stages, contemplates all the compo-
nents directly and indirectly involved and their relationships, and ends with the steady production re-
gime achieved.

The meta-integration will allow better understanding of the complexity as a result of the integration
of one or more projects and the context in which they are being inserted, from the early commissioning
planning. The concept here presented converges both to the program management standard (ISO 21503)
as well to the text of portfolio management standard (ISO 21504).

2 - SETTING UP A TRAGERY

It is common to observe the ordinary practice of setting and announcing the inauguration date of a proj-
ect not yet started, without any reliable information about their relationships with other elements to be
built, under construction or even existing ones.

The deflagration of the contracting process without a study of the project scope external dependencies
and, also, without start-up plan definition is a trigger of problems and conflicts among stakeholders,
with repercussions in meeting the contractual requirements and, often, the project’s failure common
cause.

In order to make the reading of this subject a little more objective - complexity and integration - in the
projects and megaprojects context, we’ll replace these related terms by “system” word, here defined as a
set of elements, including those existing ones and already operating, interacting to perform a function.

One can observe the complex system vulnerability, shown in figure 1 below.

**Figure 1** - Gaps in megaprojects. (Merrow – 2011)
3 - COLLECTIVE INTELLIGENCE, THE TEAM AS A SOLUTION.

Intelligence, from latin: intelligere (understand or comprehend). It is a word composed of íntus (within) & lègere (collect, choose, read), which matches to our active quality to choose among many, namely: to read between the lines. Collective, from the latin collectiva (which encompasses or comprises many things).

The concept, enhanced by etymology, reminds us of the way we build knowledge. An integrated team of experts is able to solve problems that individually would be impossible with the same quality level.

It is necessary to face up the problem’s complexity with the team’s complex intelligence.

Figure 2 shows the importance of an integrated team.

Figure 2 - The importance of a Team integration (Merrow – 2011)

The proposal presented here seeks to reduce the “blind spots” which result from individual project planning, not considering the complexity of the system that will be established or modified and the framework in which it will take place.

The analysis of the project’s implementation, if carried out by a multidisciplinary experts team is able to identify all the necessary relationships, including those least valued and most remote that, if neglected, will impact on the system in which the project is contextualized.

Figure 3 shows the importance of knowing the problems in advance.
4 – THE INTEGRATION

When it comes to the management systems, complexity is a natural attribute and should not be underestimated. Only from an interdisciplinary study that searches for common and complementary properties in the parts of the system it is possible to identify the demands for infrastructure, energy, inputs, products and services in project implementation scenario.

On the one hand, we have the perspective derived from the experience of project implementation activities, communed by the team of Construction & Assembly (C&A), but one cannot ignore skills of the Operation & Maintenance (O&M), whose abilities about start-up lies in the industrial plant’s team.

The integration of these teams and their knowledge is the key to mapping the interfaces and, therefore, to prepare the start-up sequence plan, which should address in an integrated manner all the activities encompassed during the transition’s stage between construction and operation.

5 – SPECIFIC TERMINOLOGY

For a better understanding of our proposal, we present the following definitions:

- Commissioning: process by which a project progresses toward to Commercial Operation, by controlling the quality, ensuring reliability and the acceptance of a delivery. It is divided into conditioning, pre-operation and start-up.

- C&S_CC (Streams & Services for conditioning): milestone, which corresponds that all demands of Streams & Services for conditioning’s start are met.
- Conditioning: set of activities during the end of electromechanical assembly, comprised by tests and inspections, which ensures the security and integrity to start the pre-operation.

- CMC (Assembly & Conditioning Certificate): milestone, which corresponds to the certificate, which ensures that the subcomponent is assembled, meets the requirements and is fit for pre-operation.

- C&S_PO (Streams & Services Pre-Operation): milestone, which corresponds that all demands of Streams & Services for pre-operation's start are met.

- Pre-Operation: set of activities that simulates the system working condition, evaluates performance and certifies the capability to operate as specified (according to design specification) in order to make the startup viable.

- TT (Transfer Agreement): milestone that corresponds to the issued certificate of conformity, attesting the functionality of a component, and that it is able to perform during the startup. Once accepted by the operators' team, it implies in transferring the system to the client.

- C&S_PT (Streams & Services Starting-Up): milestone, which corresponds that all demands of Streams & Services for the system's startup were met.

- Startup: activity to be performed by the operation staff in order to certify the facilities operation, assess their performance under realistic conditions and start commercial production of the system.

- TP (End of Startup): milestone, which corresponds to the end of starting-up operational procedures, ensuring that the system is in commercial operation.

- Stream: flow required by a component to perform a certain role, which may be from both material nature (eg drinking water) or immaterial, like energy (eg electricity) or information (eg data).

- Service: task required by a component for its operation, which may be of any nature (eg to perform a chemical analysis).

- Protagonist: A system component that can be considered a “client”, that demands a delivery (stream or service) that must be delivered by a co-operator (supplier) through an interface (connector).

- Co-operator: a system component that must support the protagonist requirements (client). It can be considered a “supplier” that meets a demand (from the protagonist) for a supply (stream or service) by an interface (connector).

- Connector: milestone that corresponds to an interface (physical or virtual) that establishes the relationship (dependency or interdependence) between components (protagonist and supporting) to enable the required flow (stream or service) for commissioning or operation.
6 – INTERFACES MAPPING - PLURIBUS UNUM

How to relate multiples chronograms of a system and consolidate them in a single model, an integrated schedule, to allow, at first, the contract planning of hiring, and then, the monitoring and controlling of each component?

The systemic nature that is established in the activities during the final phase of construction & assembly (C&A) at the transition to the preliminary activities of the early phase of operation & maintenance (O&M), although short in duration, deserves to be analysed.

The contracting strategy must meet the requirements, imperatives and specifics, from a start-up sequence map that includes the relationships between system components, and also those between the system and the context in which it is being inserted. The situation is worsened in the case of megaprojects, usually performed through multiple contracts, where systems involved (eg industrial plants) are used to exchange streams or provide services to each other or with existing facilities. An inadequate first time start-up sequence will compromise the implementation, causing turmoil in contractual relationships, delays, additional costs, revenue deferral and, inexorably, increases chances of failure.

A connection point between the C&A domain and the O&M domain will be the beginning of the answer on how to integrate the numerous schedules. This convergence matches to CMC, which is a management milestone usually highlighted from the set of classic C&A activities, as well as, a remarkable point of the beginning of O&M planning.

The proposed approach is based on meeting the protagonist's demands, necessary for carrying out each commissioning stage of it, which will be supplied by one or more co-operator, through streams or services (C&S).

The method assumes that a multidisciplinary team, formed by experts in C&A and O&M, run the system's breakdown into its components, its classification, its interfaces and relationships ordering searching on each basic engineering project document.

Then, the team should share experiences and knowledge to raise up undocumented items that resulted from previous experiences, contractual requirements etc. In this way, it is also possible to identify the "knowledge gaps" that correspond to not explicit demands, but required for the system's commissioning or operation, and that should be considered in the interfaces mapping, such as trained operators, revised operating and maintenance manuals, licenses and permits, ICT services, extra demand for utilities, laboratory analysis, specialists availability etc.

The satisfaction of all protagonists' demands for streams or services by all co-operators will be possible from the identification of all dependencies and interdependencies, inherent to a complex system. The interfaces between components of a system are represented by connectors that allow their relationships, by exchanging streams or services in an integrated way.

The main product of the expert group is a system interfaces matrix with all attributes considered nec-
ecessary for its components' integration. It should adopt the principle of planning by successive waves, ensuring the maintenance of this matrix, simultaneously with the project’s development.

Figure 4 shows the structure for the data collection during meetings with experts, when all necessary streams and services (C&S) for the electro-mechanical completion, pre-operation, startup and operation of each project, highlighting the interdependence that exist on the whole set, a reality that goes beyond the limits of C&A thereof, and organizing them in a database that will be used to prepare the integrated schedule.

**Figure 4 – Structure of Interface Data Bank**

In order to facilitate the methodology application, it was created a device that ensures the integrity and management of interfaces based on C&S, improving communication among stakeholders, as well as the dissemination of collective knowledge, ensuring better understanding of the context and enhancing the management of each individual commitment and deliveries previously contracted.

Figure 5 shows the screen of this tool, whose product is the system interfaces matrix.
7 – THE TIME DIMENSION

Once completed the needs mapping of each project, the network of relationships will show that all mapped streams and services are seen paradoxically by many actors involved in the process, sometimes protagonists (clients), sometimes supporters (suppliers).

Thanks to the expert group, we have a perspective that allows us to understand the relationships needed for conditioning, pre-operation, startup and operation of each system component.

However, knowing who demands, why demands, what is demanded, who provides and how provides is not enough, because it still lacks to define when we can start each of the preliminary stages of each component start-up.

Figure 6 shows the logic applied to the connections of collected data in an integrated chronogram, establishing the time dimension and, thus, obtaining the answer to “when”.

Figure 6 – Logic stablished for C&S connections (INTERFACE).
The system interfaces matrix allows building a network of relationships between the various chronograms, from each milestone CMC up to each milestone TP, when then the protagonist unit (client) is able to exercise its co-operator (supplier) beside its pairs.

The model allows the identification of "loops" resulting from mutual dependence relationships (interdependent) and that shall be neutralized.

As an example, the case of a compressed air supplying unit which requires cooling water for its compressors. However, the unit that cools the water also needs compressed air for its pneumatic actuators of current flow control to be provided.

Among the alternatives to suppress the “loop”, there are: an engineering design review; meeting the demand by external supplier; the use of a temporary installation.

The possible non-attendance by a supporting, at the right time, of a demand for C&S may result in delay and cost increase in other system components (domino effect).

It is essential that the chosen solution should be considered in the updating of system interfaces matrix and, thus, it must have repercussions on the planning and be represented in the integrated schedule.

Reconstitution of this scheme of relationships in the integrated chronogram and, then, the probabilistic risks analysis, associated to activities prior to the various CMC milestones of the various chronograms, allows to identify the best time to the deflagration of each project. This time corresponds to the time period applied retroactively, required for all the previous steps of the CMC.

8 – THE CHRONOGRAM SETUP

The system decomposition and its needs' understanding, according to its interfaces matrix, shown in Figure 7, allows its reproduction in a structured manner in the integrated schedule template where are inserted each of its components, their relationship attributes and their respective connectors, in each of the steps deemed necessary for individual and collective management of time. The model, thus built, makes it possible to represent all network interfaces in the system integrated schedule, restoring its complexity and keeping it under control.
The reconstruction of the complexity, mapped in the interfaces matrix, and its representation in the integrated schedule begins with a Work Breakdown Structure (WBS). There are three modules that allow the reconstruction of the system complexity, as Figure 8 shows.

**Figure 8 – Work Breakdown Structure for Projects Metaintegration.**

The Integrated Projects Module contains the classical steps that happen in a typical project, from contracting to the respective needs of C&S, which allow the project to move to the commissioning steps and to get into startup stage.

Figure 9 shows one of several projects that comprise an integrated chronogram, highlighting the impact of a failure in meeting a C&S required for the pre-operation, resulting in delay of the planned start up.
Figure 9 – Integrated chronogram from interfaces and C&S

Figure 10 below shows the Delivery (C&S) Module containing the date of availability of all the C&S. These dates refer to the end of startups (TP) of the C&S suppliers, as shown in Figure 6.

Figure 10 – Dates of availability of deliveries (Streams & Services) of the system.

The Interface Milestone Module contains milestones derived from the interfaces matrix that correspond to projects’ dependency relationships. Each of these relationships, which is established from an C&S, is represented by a pair, where the “demand” milestone sets the date of the need of a C&S by the protagonist project, in order to permit the next step as planned, and the “Receive” milestone is the expected receiving date of the C&S required (depending on the supporting project’s performance).

Figure 11 shows the behavior of pairs of milestones due to the advancement of the various integrated projects, impacting the date of beginning of the subsequent planned activities.
The gap between the dates or the misalignment between these milestones will flag whether a C&S is being offered to the project on focus (protagonist) at the time of their need. The impact of each of these gaps in the whole schedule network will indicate the possibility that the project on focus (protagonist) have its startup date held as planned (date of “demand” milestone later than or equal to the date of “receive” milestone), or have its startup date under the threat of not being met (date of “demand” milestone before the “receive” milestone date).

In each project milestones: C&S_CC, C&S_PO and C&S_PT are the result of the integration of C&S, present in the module: Deliveries (C&S), necessary for the activities supported by the Interface Milestone module (conditioning, pre-operation and startup). The maintenance of the integrated schedule should ensure the preservation of its structure according to the interfaces matrix, and certify that the planning and the monitoring of its activities’ performance are updated and synchronized from the various chronograms of each system components.

From the METAINTRODUCTION, the monitoring of all system components can be performed by a matrix that shows the gap between milestones “demand” and “receive”, as shown in Figure 12.
The literature is unanimous in strengthening integration and communication as key roles of the project manager.

The presented methodology contributes to greater efficiency in managing projects and megaprojects, as well to enable integrated planning, to prevent production losses and the postponement of revenue arising from lack of synchronization between the demand and supply of the various streams and services required for the operation of a complex system. It also promotes communication between the parties by providing the necessary visibility to program and portfolios managers on the status of its components. Indeed, it’s a structured and consistent method for assessing performance of time and costs, and also important to assess the exposure to the tolerated risk by the organization to its portfolio.

The system's integrated schedule model allows the formulation of guidelines on what, how and when each project manager should plan, monitor and control your project taking into account the inexorable constraints of the system.

The METAINTEGRATION is the technique for reconstituting a set from its parts rearranged depending on the needed relationships, reestablishing the system and its complexity.

Its application envisages the recommended in ISO 21503, particularly regarding to the integration of a program components. In addition, as recommended in ISO 21504, it increases the effectiveness in the portfolio's iterations, improving the components reporting progress, providing strength to risk management and to the rescheduling from the integrated monitoring and control, pursuing for a strategic benefit.

This methodology, in a case of real application in two megaprojects, resulted in successful detection of risks associated to interdependencies between them, allowing the rescheduling on time to fix the situation. These projects are closely interdependent between its industrial units, supplying C&S to each other, such as water, steam, electricity, gas flaring, operators, products transportation and storage, laboratory analyzes, etc.

Our experience reinforces our conviction about the timing of the methodology application, that is prior to the planning of procurement, being, in fact, an input to that.

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Cost Reduction in the Application of Shipping Containers in Construction

João Felipe Mariano Woelfer Olczyk, Matheus Kock, Thiago Luis Rodrigues, Bruno Thiago Tomio

ABSTRACT

This study reports on a survey that evaluates the feasibility of using shipping containers for the purposes of home construction, and as a means of cost reduction. Furthermore, the study adds practical alternatives to present knowledge for the improvement of comfort in homes and rooms built by shipping containers, as well as a real decrease in costs. Also, a comparative price analyses of conventional materials and that of shipping containers was conducted, and research was done into matters such as social critique of existing buildings made possible by government initiative. Within the study the possibility of fast, simple and relatively lower costing projects were acknowledged, as were social and environmental benefits that in turn increasingly strengthen continuation of such endeavors.

Keywords: Container. Sustainability. Social Habitation. Cost Relationship.

1 INTRODUCTION

The current construction market presents several innovative and technological options. Some of these arise through research and studies of building elements while others result through means that try to meet societal needs as a whole.

It is in this direction that the concept of using shipping containers as material for housing or offices construction ensues. Apart from being seen as a sustainable building method, in which materials that would otherwise be discarded are utilized, as is known in recurrent research, the utilization of shipping containers may enable an approximately 35% cheaper construction process than those using conventional materials in Brazil.

Extending the study to the process community creation, it is possible to adapt shipping containers to social housing, which according to Bonduki (1998), “is the housing produced and financed by the State for the low-income population”. Therefore, presently in Brazil, it is possible to frame this study in the Federal Government’s program “Minha casa, minha vida”, where the state bank Caixa Econômica Federal finances housing to the low-income population. This program is intended for those with low buying power, and
as such the program defines requirement conditions, to which the main requirement is a gross family income of up to R$ 5,000.00 per month. The property must be used for explicitly for housing, and the monthly mortgage must not exceed 30% of the monthly gross family income.

The idea of a home-container contributes to the idealizations of Bonduki (1998), in which it includes low-cost technology as an alternative to social housing, and since there are a large quantity of containers available for utilization in construction it would have a major impact for the low income population. However, a question that could bring real advantages to the use of shipping containers is persistently criticized, and it is the project quality factor. According to Palermo (2007), in the economies of scarcity, the housing problem has led to pure and simple dimensional reduction and the lowering of housing standards to budget for lower cost in both homes and container offices. Since project quality may have a great impetus, making such projects available to the low income public will render better quality of life, giving social housing programs a good impression and consequently reduce poverty in the peripheries.

Faced with these arguments, the aim of this study was to determine the feasibility of building houses by using shipping containers as a means of minimizing costs once compared to conventional masonry construction.

2 METHODOLOGY

The study was conducted by four students from the Civil Engineering course at the Regional University of Blumenau - FURB, from the state of Santa Catarina / Brazil. In the organization and development of this study, weekly meetings took place with the authors of this paper.

For the accomplishment of the project, research was initially performed on academic Google and the portal of CAPES (Higher Level Personnel Improvement Commission). The aim being to find papers on the theme with information on the utilization of shipping container as a means to minimizing costs in the construction of houses, and what impact it would have on the environment in which it is placed. Few publications were found about on the topic, all of which appear in the references.

As a microeconomic analysis, four companies that offer shipping container service in the area of construction, and that interfere in the economy of the state of Santa Catarina were contacted and asked to provide estimates. The contacted companies were: Itajaí Containers (Itajaí/SC); SC Containers Habitáveis (Içara/SC); Evolution Empresas (Itajaí/SC); Ferraro Container Habitat (Florianópolis/SC).

From these aforementioned companies, only Itajaí Containers and Ferraro Container Habitat responded and gave the requested estimate, each giving examples of a project of a shipping container adapted into a house.

The company Itajaí Containers sent an estimate of a shipping container house containing 30m² with external measures at 12.19 meters long x 2.44 wide x 2.90 high and internal measurements at 11.80 meters long x 2.20 width x height 2.53. The constitution of the house in general, consists of the following components:
- Galvanized steel for placement plaster ‘Drywall’ system;
- Thermal and acoustic insulation in pet wool with a thickness of 50 mm;
- Coating gypsum board with a thickness of 12.5mm;
- Rubberized baseboard at 8cm tall x 1.5cm wide in white;
- Frosted acrylic paint for the internal area (customer preferred color);
- Synthetic exterior paint semi-gloss (customer preferred color).

Additionally, all composite materials in every room and their respective brands were specified.

The final estimate of this module was R$ 32,000.00, not taking into account land value and the cost for the foundation needed to secure the container.

The establishment also sent the architectural design model of the container module, along with some pictures of it in its final stage.

**Figure 1** – Container house design model of the Itajaí Containers company.

Source: Itajaí Containers, 2016.
Figure 2 – Front external view of budgeted module.

Source: Itajaí Containers, 2016.

Figure 3 – Background external view of budgeted module.

Source: Itajaí Containers, 2016.
Ferraro Container Habitat, another company to respond to our estimate request, sent two estimates of
different services. In this case, the institution provided not only module designs at their final stages, but
also informed that the architectural design could be arranged to fit according to the customer's desires,
thereby leaving everything including the project design to each individual.

The response given showed two design patterns: Standard, which is classified at a lower quality and Su-
per Premium, which is set at a higher standard.

- The standard design is constituted by the following elements:
  - Window frames Blindex;
  - No internal lining and original insulation;
  - Ceramic floor;
  - Finishes, metals and basic bathroom installations;
  - Painting (internal and external).

The final estimate of this module was R$ 39,000.00, not accounting for transport, crane installation,
basic infrastructure in the terrain, approval rates and the costs of printing and ART's (Technical Respon-
sibility Note).
The Super Premium standard comes at with the following construction elements:

- PVC window frames;
- Internal lining, original insulation;
- Floor vinyl with wood style strip 3mm;
- Box in the toilet;
- Embedded finishes, metals and top of the line bathroom installations;
- Painting (internal and external).

The final estimate of this module was R$ 59,000.00, not taking into consideration the costs of transport, crane installation, basic infrastructure in the terrain, approval rates and the costs of printing and ART's (Technical Responsibility Note).

3 RESULTS AND DISCUSSIONS

It is emphasized in the study that a location with a strong adherence to this type of technology is the city of Itajaí, in the state of Santa Catarina, due to the fact that it possesses one of the main ports in Brazil, with a capacity of frozen cargo at 160,000 tons (ANTAQ, 2012).

This flow in the region, brings a significant supply of shipping containers to the state, which, together with a growing demand, may acquire increasingly more market share from buildings made of conventional concrete.

3.1 Construction system

Through research on the different constructive system of a shipping container, it was possible to identify that at Soldatopo from Mairinque/SP, a company situated in São Paulo, that the structures are made in galvanized steel profiles, galvanized steel sheets, shaped or ‘isopanels’ at the closing of the walls, coverage is done in galvanized steel tiles, floor in fitted with waterproof plywood and the junction between the walls is done by rivets, bolts and nuts (SOLDATOPO).

Moreover, the facilities and finishes follow the following order according to the same company: doors, windows and shutters are made from the same material as the walls or others available in the market, external finishing wall and natural ceiling in galvanized steel, isopanel or paint on synthetic or polyurethane enamel, the wall internal finish and ceiling is natural in galvanized steel, isopanel, painting or thermo-acoustic coating (EPS) and MDF or laminate -melamine, the floor finish is natural in plywood, synthetic rubber, vinyl rug or carpet, the electrical installation is external of PVC channels or galvanized conduit and the hydraulic system is made in the distribution of PVC pipes, white crockery in pots, sinks and urinals in white porcelain or stainless sheet metal and chrome steel or PVC (SOLDATOPO, 2015).

The choice of the foundation type usually follows the same patterns of a conventional build, differing only by the type of soil to which it is inserted.
3.2 Relationship between masonry prices and habitable containers

To relate the conventional masonry construction and container construction prices, it was determined previously a pattern commercial and residential with high standard, medium standard and low standard for single-family residence (R-1). Along with this, it was also determined the standards: free floor commercial (CAL-8) and commercial rooms and shops (CSL-8), which would be the equivalent standards to the objective of this research. The costs of these constructions, in a conventional masonry pattern are shown in Table 1.

The information was taken from the Basic Unit Cost (CUB) from Santa Catarina. Analyzing these prices in macroeconomic terms, these values are now updated with the tax rates and inflation for the month of July 2016.

**Table 1** Prices of the 30m² construction in conventional masonry.

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Low Standard/m² (R$)</th>
<th>Low Standard /30m² (R$)</th>
<th>Medium Standard/m² (R$)</th>
<th>Medium Standard /30m² (R$)</th>
<th>High Standard m² (R$)</th>
<th>High Standard /30m² (R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family Residence</td>
<td>R$ 1.462,65</td>
<td>R$ 43.879,50</td>
<td>R$ 1.762,73</td>
<td>R$ 52.881,90</td>
<td>R$ 2.125,56</td>
<td>R$ 63.766,80</td>
</tr>
<tr>
<td>Commercial Floor Free</td>
<td>-</td>
<td>-</td>
<td>R$ 1.692,70</td>
<td>R$ 50.781,00</td>
<td>R$ 1.794,45</td>
<td>R$ 53.833,50</td>
</tr>
<tr>
<td>Commercial Rooms &amp; Stores</td>
<td>-</td>
<td>-</td>
<td>R$ 1.465,77</td>
<td>R$ 43.973,10</td>
<td>R$ 1.591,03</td>
<td>R$ 47.730,90</td>
</tr>
</tbody>
</table>

**Source:** CUB Santa Catarina (June/2016).
Making a connection with the costs of a 30m² shipping container house (R$ 32.000,00 - R$ 59.000,00), it can be seen a slight advantage in the prices of a container house even though there are still a few specified costs in the previous budget, enforcing the creation of a project in this area in a low standard of residence.

As a means of clarifying the economy used in the use of shipping container for building houses, the Table 2 shows the comparison between the value of a 30m² house built with shipping container and conventional masonry, represented by the value of CUB.

**Table 2** Cost difference between the construction of a 30m² house built with conventional masonry and construction with container.

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Padrão</th>
<th>Container Value</th>
<th>Total value referring to CUB</th>
<th>Economy with the utilization of the container</th>
</tr>
</thead>
<tbody>
<tr>
<td>Itajaí Containers</td>
<td>Unique</td>
<td>R$ 32.000,00</td>
<td>R$ 43.879,50</td>
<td>27%</td>
</tr>
<tr>
<td>Ferraro Container Habitat</td>
<td>Standard</td>
<td>R$ 39.000,00</td>
<td>R$ 43.879,50</td>
<td>11%</td>
</tr>
<tr>
<td>Ferraro Container Habitat</td>
<td>Super Premium</td>
<td>R$ 59.000,00</td>
<td>R$ 63.766,80</td>
<td>7%</td>
</tr>
</tbody>
</table>

*Source: CUB Santa Catarina (junho/2016), Itajaí Containers e Ferraro Container Habitat.*

Through this table it can be seen that according to the values of the supplied patterns, a construction utilizing container as a building module becomes at most 27% more economical than a conventional masonry construction (which system is the most used in the country for this purpose). Thus, is notable the advantage of using this system, especially for the low-income population is visible.

Another advantage of using a shipping container for the construction, concerns to the reduction of construction time. That is, according to the contacted companies, construction takes up to 90 days.

In addition, high-standard buildings can also use shipping containers. This is because it is a technology that minimizes costs and also enables standard and distinctive architecture to be viable, as presented in the following figures.
4 FINAL CONSIDERATIONS

The results that have been found regarding the creation of an enterprise with projects in the containers indicate positive responses, since analyzing this creation of a micro and macroeconomic way, prices com-
pared to conventional masonry, are smaller, and have the same features after finished, differing only in the construction process.

Still is possible to point out that these projects are viable in both construction of social habitation, and in homes and upscale companies because it makes feasible to the customer, a lower price and a chance to escape from the building standard. A fact which is widely criticized by architects and engineers from all over the world, where many low-standard housing projects, end up following a “square” aspect and with companies only seeking for the profit in these endeavors, as long as for the same price, could be designed homes and commercial rooms with more comfort and style.

5 REFERENCES


Result Analysis of the Application of the Total Productive Maintenance In Food Industries

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ABSTRACT

In order to meet the global needs of an increasingly globalized and competitive market, Total Productive Maintenance (TPM) is presented to industries as a strategy that results in reduced costs, improved quality and increased productivity, leading to more competitive prices. Thus, the present paper aimed at presenting the historical approach, the concept and the advantages of TPM implementation in industries, and also explaining this new strategic tool for cost reduction and quality improvement. The research analyzes three important food industries where this system was adopted as cost and quality management strategy, and it is justified due to the importance of TPM to modernization, competitiveness, and as a cost and quality management tool of industries in a globalized world. As for the methodology, it was applied documentary qualitative research combined with a multi-case analysis based on examples of TPM application. In this manner, this article aims to present the TPM as a strategic tool for cost and quality management and quality to be used by all industries. It was also verified that the focus of TPM in the companies in question was to eliminate traces of loss, waste, breakages or failures, aiming at the full use of the system, which is also a manner of professional growth through constant improvement of the use of relationship between professionals and their working material. Finally, it is noteworthy that in today’s competitive market industries that sought to respond more quickly to changes in their production systems and customer expectations were more likely to be ahead of others, with an efficient cost management and an increasing in competitiveness and profitability. Thus, this objective was fulfilled since TPM is presented as suitable tool for the management of costs and quality.

Keywords: TPM. Food Industry. Competitiveness.
1 INTRODUCTION

The present paper aims to approach the results obtained from three food companies in what concerns the implementation of Total Productive Maintenance according to the theme “RESULTS ANALYSIS OF THE APPLICATION OF THE TOTAL PRODUCTIVE MAINTENANCE IN FOOD INDUSTRIES”.

Due to the globalization of the economy, there is the need for greater quality of services and products, but for a long time, industries usually operated by a corrective maintenance system in which waste and loss of time and money were constant.

The option for Total Productive Maintenance (TPM) as a topic is justified due to its importance for the industry in general and for the food industry; firstly because they are companies in the industrial area of activity and, consequently, because they are developing the application of TPM in its production lines in order to significantly reduce losses and become increasingly competitive in the Brazilian market.

The research question is: what are the results from implementing TPM in the food industry?, and, in this manner, this paper aims at analyzing the results of the application of TPM in the food industry so it is possible to deepen the methodology knowledge by means of literature review, study, analysis, and evaluation of its application in the production line of three food industries, observing problems and solutions achieved when TPM was applied.

Finally, it is noteworthy the paper is relevant because it aims to help those interested in the subject and disseminates knowledge of TPM methodology applied in the food industry.

2 THE IMPORTANCE OF THE TOTAL PRODUCTIVE MAINTENANCE

Over time, by analyzing waste of materials, time and money that was due to the use of corrective maintenance, the preventive maintenance has been developed to Total Productive Maintenance (TPM) for a greater efficiency of prevention and productive maintenance, based on individual respect and full participation of employees by improving the business, material and human structure, resulting in a higher returns (MARTINS; LAUGENI, 2005).

The reduction of time related to breakages, failures and equipment adjustments increases the availability, allowing its maximum utilization, and it depends, among other factors, on the organization and planning of management maintenance activities, which, in turn, can be improved by applying TPM techniques (CHUNG, 2012).

A redução dos tempos relacionados a quebras, falhas e ajustes de equipamentos aumenta sua disponibilidade, permitindo sua máxima utilização, e depende, dentre outros fatores, da organização e do planejamento das atividades de manutenção administração, que, por sua vez, podem ser melhoradas pela aplicação de técnicas do TPM (CHUNG, 2012).

The efficiency in production systems is necessary for organizations which act in the global market - especially for food industry, which is the focus of this article - because companies become increasingly...
competitive and willing to conquer more markets. Particularly in the food industry, that throughout the processes of transforming raw material into finished products has some losses of raw materials, labor, finished products, and electricity, for instance. Thus, deficiencies in maintenance management of machines and processes result in losses for businesses, and the amount of such losses can be the difference between their success and failure of these (CHUNG, 2012).

In this manner, the importance of TPM today is much more than just the mere maintenance as it was before, and it is seen as a management philosophy that works in organizational form, in the behavior of individuals, and how they deal with problems when they see them as a whole, thus generating commitment from all participants in the process (TAKAHASHI, 2006).

It is also important to say that TPM is a daily part of businesses and may be enforced in several areas, enabling the almost total reduction of waste, failures, re-work and financial losses by having greater competitiveness and quality (MARTINS; LAUGENI, 2005).

In this manner, Suzuki (1994) states that:

[...] companies that apply TPM have the following results: a) reduction of damage to equipment, with a significant reduction in downtime and short breaks; b) reduce quality defects and customer complaints; c) increase productivity; d) reduction of labor costs, inventories and accidents; e) increased employee commitment (SUZUKI, 1994, p. 47).

The following chapter discusses the background of the Total Productive Maintenance.

3 HISTORY OF THE TOTAL PRODUCTIVE MAINTENANCE

The history of the Total Productive Maintenance begins in Japan, specifically in the company Nippondenso Co. in early 1960, and its goal was to enable the Just in Time model, where nothing is to be produced, transported or purchased before the right time. It was the Toyota Production System to improve equipment reliability (JIPM, 2008).

In 1969 the term Total Member Participation Preventive Maintenance was shortened to Total Productive Maintenance (TPM), and in 1971, Nippondenso Co. received the PM Award for excellence in preventive maintenance system (NAKAJIMA, 1989). The application of TPM by Nippondenso Co. had the support of the Japan Institute of Plant Engineers (JIPE), an institute that in 1981 gave rise to the Japan Institute of Plant Maintenance (JIPM), responsible for the design, development and dissemination of TPM in companies in Japan and many other countries (JIPM, 2008).

The initial methodology was focused on maintaining the equipment in order to eliminate the losses generated by them; however, since organization is a complex and interconnected organism, the improvement of performance due to maintenance was limited by other sectors that did not follow the ideology of the TPM principles and thus generated the need of development of the scope of these principles to others production sectors (NAKAJIMA, 1989).
Then, in 1989, the definition of TPM was revised to encompass the entire production sector, focusing on the production process, eliminating the loss of processes and equipment. Currently, TPM encompasses all sectors of organizations through an integrated management whose focus is to meet the organization’s business guidelines (JIPM, 2008).

3.1 TPM Concept

TPM consists of a management system that provides maximum results for organizations that adopt it. The acronym stands for Total Productive Maintenance, which includes several maintenance activities aimed at improving the performance and productivity of equipment and sectors of organizations (KARDEC; NASCIF, 2009).

Thus, according to Kardec and Nascif (2009), the concept of TPM is:

[...]a management, which seeks to transform traditional models of administration by means of continuous elimination of waste, focusing on the ongoing development of the organizational structure, through the constant improvement of staff, means of production, and quality of products and services (KARDEC; NASCIF, 2009, p. 12).

According to the JIPM (2008), TPM is:

the ongoing evolution of [...] is a form of management that seeks continuous elimination of waste, obtaining the structure by means of constant improvement of staff, means of production, and quality of products and services (JIPM, 2008, p. 02).

So in accordance with the concept of TPM, each letter (T, P and M) has its particular meaning:

T = (Total) means "overall efficiency", aiming at the creation of an organizational structure that focuses on more efficient production systems, creating in the workplace a mechanism to prevent losses and reach zero defect, zero accident and zero breakage. Furthermore, "Total" also encompasses all organizational sectors, with the participation and cooperation of everyone, from senior management to shop floor workers (XENOS, 1998).

P = (Productive) refers to the search for more efficiency in production systems and focus on zero accident, zero defect and zero breakage / failure by reaching real efficiency (XENOS, 1998).

M = (Maintenance) to the useful life cycle of the production system, focusing on an unique process system of production in the factory and in the administrative system of production (KARDEC, 2009).

This maintenance of the production management system is, therefore, the preservation of the system in its best condition by means of the ongoing training of an organizational structure capable of surviving
to market changes through the constant pursuit of efficiency in an effort to adapt to cyclical changes (KARDEC, 2009).

3.2 Advantages when applying TPM

One advantage when applying TPM by industries is that products must be competitive in the current market, and there must be cost reduction in production with no decrease of quality for greater subsequent profitability. Thus, these industries will be able to stay longer in the market since the winner is not the strongest one, but those that respond quickly to rapid changes in demand and customer expectations (SLACK; CHAMBERS; JOHNSTON, 2002).

According to the Japan Institute of Plant Maintenance (2008), implementing TPM results in the following:

- Increased productivity (value-added);
- Reduction in sudden breakages and failures;
- Increased operating rate of equipment;
- Reduction of failure rate of manufacturing or services;
- Reduction of complaints by the customer;
- Reduction of manufacturing cost;
- Lower rate of accidents and sick leaves;

Thus, it is essential to improve industry results by totally eliminating large losses and searching for maximum equipment efficiency (SLACK; CHAMBERS; JOHNSTON, 2002).

4 METHODOLOGY

In accordance with Gil (2010), research methodology is a set of actions proposed to find a solution based on scientific, rational and systematic methods. It can be also understood as a detailed, sequential group of methods and scientific techniques to be carried out during research in order to achieve the originally proposed goals and, at the same time, meet the lowest cost criteria, higher speed and efficiency, and more reliable information (BARRETO; HONORATO, 1998).

Thus, the methodology applied to the present paper was the documental qualitative research combined with a multi-case analysis based on examples of TPM application, and three papers were selected for comparative analysis, as shown in Table 1.
The instrument used for data collection was the documental qualitative research subsequently turned into a descriptive text. The first part of the paper characterizes TPM and approaches history, concepts and benefits by using bibliographic material found in specific books of the area, as well as articles.

In the second part it was used the methodology of comparative analysis in three previously selected food industries - for confidentiality reasons, the name of one of them could not be revealed in the paper. The analysis was divided into conditions of the food industry before the TPM; application of TPM, and analysis of changes and results obtained with the application of TPM.

Regarding data collection, the research was conducted in September and October 2015 and concluded based immediately after the deadline of the research, when the analysis was made based on the works referenced in this work.

5 RESEARCH ANALYSIS

5.1 Conditions of the selected Food Industries before TPM

At first review, it was observed that before the application of TPM the food manufacturers verified the main mistakes made in their production processes. Unilever Bestfoods, Pouso Alegre unity, market leader in mayonnaise production, wanted to become more competitive, but faced several losses not previously and systematically solved:

Large number of non-detailed equipment failures; small breaktimes were not evaluated; decisions and actions were not based on data; there were no tools to detect root problems; problems were assessed as “usual” in operations; repairs did not prevent reoccurrence; 40% of the produced items were not delivered on time, quality and quantity were correct; there was no correlation between quality and performance of equipment (FREITAS, 2002, p. 03).

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Company</th>
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<tr>
<td>FRANCISCO, I. Et al.</td>
<td>TPM implementation in phase of Autonomous Maintenance.</td>
<td>Not disclosed for confidentiality</td>
</tr>
<tr>
<td>FREITAS, Marco.</td>
<td>Application of TPM Total Philosophy - A Case Study.</td>
<td>Unilever Bestfoods.</td>
</tr>
</tbody>
</table>

Source: Research, 2015.
Bomgosto Food Industry, whose trade name is Vitarella brand, operates in the Brazilian Northeast area of activity in biscuits and pasta, and presented the following problems:

Poor maintenance of equipment; lack of awareness of employees about abnormalities in equipment, and lack of communication between staff and maintenance sector about the equipment’s conditions (CHUNG, 2012, p. 81).

The third industry is a multinational company in the food segment (unidentified), located in the state of São Paulo, Brazil, and has approximately 2400 employees. Their major problems are:

Machinery and equipment presenting high rate of stops and breakdowns, affecting the performance and efficiency of equipment, impacting on company’s goals (FRANCISCO, 2014, p. 07).

After exposing the main problems in the analyzed industries, it will be made a presentation of how TPM was applied in these industries.

4.2 Application of TPM

A common factor among the analyzed industries is the prior notice to collaborators on the implementation of TPM, as well as its concepts and purpose.

In the machine maintenance sector of Unilever Bestfoods, it was observed that the implementation of TPM was not understood by many employees, who feared losing their jobs due to the improvement of machines. The situation was solved because less downtime would not mean that employees should be fired: some of them were kept in the same sector, others were transferred to support areas. In this manner, other changes were applied: in autonomous maintenance, pilot line operators were trained to perform the labeling of equipment, inspections and cleaning (FREITAS, 2002).

Besides, it was identified dirt sources and hard-to-reach places that should be analyzed and subsequently solved, and the employees received training for autonomous lubrication. Visual control has been applied to facilitate inspections, cleaning and lubrication. In planned maintenance, the pillar vision was defined: “to maintain and continuously improve the machinery and equipment by maximizing the assets, reducing maintenance costs and fulfilling the daily production plan” (FREITAS, 2002, p. 05).

It was also defined a specific plan consisting of the following activities:

Support for autonomous maintenance; practice inspection and minor repairs; help in the solutions of problems; analysis of repetitive breakdowns; Application of TPM tools on specific and complex failures to achieve zero occurrence; corrective maintenance only in equipment considered not critical to the operation of the plant; preventive maintenance: performed by employees to eliminate unexpected breakages and to extend the life of equipment considered critical; reduction of maintenance cost: use of TPM tools to inventory reduction,
time of preventive and corrective maintenance and maintenance of zero breakdown (FREITAS, 2002, p. 05).

The pillar of education and training was the responsibility of the HR team. They defined the mission of “contributing to achieve excellence in the performance of the plant through motivation and support of the skills of employees, consolidating TPM as a philosophy to guide all activities” (FREITAS, 2002, p. 07).

In what concerns the spirit of the business: “To be a plant recognized by the operating level, with a special culture focused on the development of people and focused on business strategies (FREITAS, 2002, p. 07). There was also a description of positions and activities that each employee would have to perform inside the factory, thus creating an evaluation system to be applied to employees and obtain the results of the training.

As for Vitarella, TPM was applied as follows:

Hiring a consultant to train the group responsible for implementing the TPM in the company, and disclosure of basic concepts and principles of TPM for all employees through lectures held by the company’s leaders (CHUNG, 2012, p. 100).

It was also established the basic pillars of TPM and the evaluation of the organizational structure and the market circumstances, vulnerabilities, and basic guidelines, which are key points to be worked out. In addition, there was a concern on training of employees of the Pillars of Autonomous Maintenance, Planned Maintenance, Focused Improvement and Initial Control.

Moreover, in order to ensure quality service in Autonomous Maintenance activities carried out by machine operators, these professionals were trained, and the training was divided into three stages currently deployed in Vitarella:

First phase - cleaning and inspection; Second phase - Elimination of contamination source (CS) and hard-to-access spots; Third phase - Preparation of the Provisional Standard (CHUNG, 2012, p. 73-76).

As for the third industry analyzed, it was conducted a staff training focusing on cleaning and inspection. In addition to functions of cleaning and identification of dirt spots due to soot, lubricants and products, there is also a checking of nuts and bolts, identification of potential problems points by using blue labels when the operator performs the maintenance, and red labels when the maintenance is not concluded (FRANCISCO, 2014).

Quanto à terceira indústria analisada, foi efetuado o treinamento da equipe, com foco na Limpeza e Inspeção. Além das funções de limpeza e identificação dos focos de sujeira devido à fuligem, lubrificantes e produtos, também há a verificação de porcas e parafusos, identificação de pontos de problemas em potencial, com a utilização de etiquetas nas cores azul, quando o operador realiza a manutenção, e ver-
With reference to eliminating dirt sources and inaccessible areas, at this stage, in addition to cleaning functions and identification of dirt spots, it is necessary to eliminate these points and facilitate access for cleaning. With regard to cleaning and lubrication standards, it was established standardized instruction sheets at intervals of execution in order to enable the application of quality Autonomous Maintenance with quality (FRANCISCO, 2014).

As for conduction and general inspection, it was elaborated manuals and visual controls, and it was also sought to meet the training schedule for the whole team so they were familiar and aware of the basic operation of the equipment and the critical issues that they could generate. With reference to the independent inspection of establishment, the operator must be able to detect problems before they occur. The objective is the implementation of inspection by using manuals and inspection standards and establishing appropriate procedures for proper inspection and evaluation (FRANCISCO, 2014).

Regarding the establishment of visual management, it was standardized on the shop floor by means of clear and comprehensive systems of management maintenance by using visual controls for the detection of defects and failures, while the establishment of autonomous management introduced policies and objectives aimed to develop the company's goals and guidelines, then consolidating improvement activities and the operators' position towards Autonomous Maintenance by strengthening their confidence. Moreover, qualified personnel performed the audit of autonomous maintenance activities, then establishing indicators and exhibiting them in panels for easy visualization.

### 4.3 Analysis of changes and results obtained with the application of TPM

After TPM was applied in Unilever Bestfoods, the following improvement was verified:

[...] there was improvement in several indicators of the industry, which in turn promoted improvement in its processes with productivity gains, quality, efficiency, and consumer reliability in the post-implantation period. The projections made by the TPM team show that after the consolidation of the methodology, the gains in relation to the defined indicators will be much larger than those achieved before the application of TPM (FREITAS, 2002, p. 07).

In what concerns Vitarella, it is observable that

[...] the implementation of TPM was well accepted by the employees, and there was great synergy and communication among them about possible machinery breakdowns, which were informed and promptly solved by the maintenance staff. There was also increased training of employees. Quality tools began to be used more often by groups responsible for continuous improvement, resulting in increased productivity and fewer losses (CHUNG, 2012, p. 105).

As for the third industry:
with the implementation of TPM by means of Autonomous Maintenance, the industry made significant gains with the reduction of losses of downtime due to machine breakdowns, reduction of setups and adjustments, as well as other factors that hampered the efficiency of the unit, thus increasing its productive capacity, efficiency and reliability of equipment, which also decreased costs (FRANCISCO, 2014, p. 22).

5 CONSIDERATIONS

It is inferred that the companies analyzed satisfied their expectations by applying the concepts proposed by TPM and by sharing knowledge and experience, combined with good working conditions offered to employees and uninterrupted pursuit of the objectives aimed at zero waste, failures and defects both in production and in providing services; and also by high quality at the lowest possible cost.

In this manner, the development promoted characterizes TPM as a methodology for ongoing improvement, whose area of operation covers the whole industry, making it a system that directs its actions in the eight pillars, together or separately, as verified.

It was also found that the focus of TPM in these companies was to eliminate all kinds of losses, waste, breakages or failures, aiming at the full use of the system, as well as establishing itself as a form of professional growth through constant improvement of the use of relationship between professionals and their working material.

Thus, the food industries analyzed, which claimed to be more competitive in today’s globalized market by eliminating costs, losses, unnecessary breaks and re-work, with consequent increase in profits and little pass-through of prices to customers, decided to implement TPM. The major grounds were passed to employees to be put into practice gradually and achieve good results, aimed at elimination of failures in production or management proceedings.

Finally, it is important to note that in the current competitive market, the industries analyzed that quickly responded to changes in their production systems and to the customer’s expectations were more likely to stand out and to increase their competitiveness and profitability. Thus, the objective was achieved since TPM is presented as a suitable tool for this purpose.

REFERENCES


The Cost Of Inaction: Waste Management Evidence From Uruguay

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ABSTRACT

Purpose of this paper

Applying DEA model and considering the cost of inaction, waste management studies department in Uruguay. The cost of inaction emphasizes the consequences of not taking action. The cost of inaction is not the cost of doing nothing; it is the cost of not doing anything in particular. It emphasizes the negative consequences of not following the appropriate action. Collection inadequate or nonexistent, waste generates strong impacts on public health and the environment, with consequent social and economic costs. In that perspective, is that the cost of inaction is a key component in the development of future scenarios: the policies, whether only designed, approved, or in the process of implantation, implanted, consolidated or longer able to be evaluated Your results. This refers not only to environmental policies but also social and regional policies affecting vulnerable populations. Finally, the results presented are not consistent with empirical observations raised. Analyze the cost of inaction is key decisions with impact on the long-term future, ie beyond the time horizon in which departmental management operates.

Keywords: Costs of inaction, Assessment Project, DEA, Waste Management

1. Introduction

For more than four decades, environmental issues have gained importance at international level, from the Stockholm Conference in 1972, incorporating the concept of sustainable development. In 1984 he began his work the World Commission on Environment and Development, in the framework of the United Nations. The document generated called “Our Common Future” also known as “Brundtland Report” published in 1987 and adopted in 1992 by the Earth Summit or Rio Conference, a milestone defining sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” In many cases the damage occurs as a result of an
action, but also as a result of inaction. That is, in many cases, loss of attention can be serious and damage caused by failure to act generates large consequences.

Efforts associated with waste management impose indirect and opportunity costs that affect the economic and financial management of institutional managers. The cost of inaction, has been identified as an effective strategy to get the attention of all units involved or responsible for the economy epidemics or disasters and compare this figure with the cost of implementing policies and programs to address (Perez-Suarez and Lopez-Menéndez, 2015).

Ruth (2010) states that it has worked with the direct costs that increase the total cost of services provided by municipalities or institutions responsible, but these are only part of total costs. Then there are the indirect costs of lost productivity due to illness and premature death, fire damage, environmental damage and intangible suffering of victims and their families. Finally, there are opportunity costs, where households and society lose the opportunity to buy something important because valuable resources are spent as a result of not taking the most appropriate action plan.

We understand that obtaining quality data on how the national economy implies the cost of inaction. These data accompanied by a projection of costs if current plans or the current trend be maintained and not apply measures to stop it.

Transmitting the cost of inaction and action, policy makers and the public are important exercises. The impact of both figures is multiplied if they can be used together to emphasize the profitability of the measures that should be followed.

2. THEORETICAL REVIEW

2.1 The concept of cost of inaction

According to Anand et al., (2012) the cost of inaction emphasizes the consequences of not taking action. The cost of inaction is not the cost of doing nothing: it is the cost of not doing anything in particular. Emphasizes the negative consequences of not following the appropriate action, but does not mean that all negative events resulting from costs of inaction. When an action or an action plan is assessed, the cost of inaction helps identify the benefits of the plan, which might otherwise have been ignored. In turn, it helps identify complementarities through various actions. From this perspective, it could be inappropriate only examine the costs and benefits of actions isolated and routed to the specific objective. For example, an action that impacts health, should be discussed with their impact on education and productivity of the economy. This implies that when evaluating an action, should be considered the implications for the sector and other sectors are linked.

Both WHO (2011) as Shonkiff and Philips (2000) suggest different concepts and definitions for the cost of inaction. According to WHO (2011) it is possible to analyze a plan of action, multiple impacts and direct costs are identified. In turn, they could identify multiple costs of inaction, but can only be quantified a few. Therefore only they are included in the costs of inaction those that can be valued, as they are to some extent under the control of those responsible for implementing the plan of action defined. In turn,
Shonkiff and Philips (2000) suggest that only those events that may be canceled as a result of actions will be considered costs of inaction. In general, different actions may suppress various negative consequences. Inevitably, these principles lead to identify and select the desired actions.

**Characterizing the costs of inaction, we identified three dimensions:**

1. Define the policy or guiding principles in determining the optimal action or optimal action plan.
2. Identify the specific action plan in respect of which the cost of inaction will be determined.
3. Select the costs to consider in the analysis.

**2.2 The principles that guide the choice of action**

The selection of an action against the hypothetical comparison of the negative consequences of inaction can be guided by the principles used in choosing the desired action. Namely:

1. Identify the negative consequences that are prevented by the action, and compare the costs avoided or eliminated with the costs of the action.
2. Add the profits generated by the selected and the costs of the negative consequences avoided action, and compare this total to costs of the action plan.
3. Minimize the cost of complying with the agreed target.

Each of these points has a frame back to evaluate actions or interventions. The desired action plan is not necessarily the one with the highest gross profit. The concept of Cost-Benefit pursue obtaining the highest net profit among the set of actions defined in the action plan.

Conceptually, the total costs of non-implementation of an action plan can be separated into:

1. Current costs for not taking any action plan (costs accordingly).
2. The hypothetical benefits for not taking action.

**2.3 What is the plan of action hypothetical?**

When the concept of intervention or action is handled it not necessarily refers to a single or actions linked to a single sector action. The action plan may involve a number of sectors and a set of actions.

Measuring the cost of inaction requires identifying the hypothetical actions that can be avoided, at least to some degree, and the negative consequences of not taking a course of action. There should be at least one action to reduce the negative effects of inaction. Typically, there are many actions that mitigate or minimize the negative consequences.
The cost of inaction will be different depending on the actions selected as hypotheses. Actions and their costs will be different if the plans or programs of action are over time or one-time actions. In turn, plans can differentiate if they generate or not generate large margin or gross profit. These options raised in Table 1.

In addition, the costs of inaction will depend on the assumptions defined in the plans of action and non-action against them will be defined. Hypothetical shares may be based on interventions that generate high gross but high implementation costs and low benefits with low implementation costs margins. Also, the hypothesis action plans may be based on a single action or multiple interventions in a sector. Finally, in situations with a common goal and a common action plan to achieve this objective, the assumptions will be given. If that plan is not implemented, the costs of inaction will emerge and may be estimated.

2.4 What costs?

The approach taken by the evaluator will determine the costs to be included in the calculation of the costs of inaction. In assessing the consequences of inaction, we must consider the experience of different people and institutions at different points of time. It is necessary to consider monetary and non-monetary costs.

In turn, when assessing the costs over time, arise three concepts: 1-an appropriate time horizon, 2-the discount rate to compare costs at different points in time, 3-estimating non-monetary costs in the time horizon. The time horizon and the discount rate will have high impact on the costs of inaction. The costs of inaction may impact a long period of time even be intergenerational issues as health, child nutrition or education. Some non-monetary costs that occur in the future should not be discounted.

However, the selection of the time horizon affects the measurement of monetary costs of inaction and non-monetary.

Many costs are easy to quantify and identify, such as costs that require cash outlays. There are also costs that can be quantified but it is difficult to identify its monetary amount, for example, infant mortality impact for their families or domestic violence costs to society. Moreover, there are other costs that cannot be quantified, even in non-monetary terms, as in the case of pain, suffering or emotional conditions.

Table 1. Intervention by type of action and gross benefit

<table>
<thead>
<tr>
<th>Program of action over time (PAT)</th>
<th>Intervention with greater gross benefit (GB)</th>
<th>Intervention with smaller gross benefit (SB)</th>
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<tbody>
<tr>
<td>PATGB</td>
<td>OAGB</td>
<td>OASB</td>
</tr>
<tr>
<td>OAGB</td>
<td>PATSB</td>
<td>OASB</td>
</tr>
</tbody>
</table>

Source: Adapted from Anand et al., (2012, p15)
In cases where it is not possible to translate the cost in monetary terms, it is important to identify and expose looking for alternative ways. Instead of identifying and calculating only the costs that can be monetized, you can resort to quantify some using non-monetary scales.

The cost quantified in various aspects may be presented as elements of a multidimensional vector. Unquantifiable costs could be listed and identified in a table. This approach allows the decision maker to identify the set of impacts, regardless of whether or not you can translate it into economic terms.

2.5 The action plans in the new context of sustainability

This creates a new theoretical framework from which a set of actions is deployed at national and international level with a holistic view and a perspective that focuses on two time frames at once contemporary action and future liability.

The methodologies that are linked to the costs of inaction have begun to develop and have different degrees of progress in various fields, in which the perspective calculation -economic, social and environmental cost of inaction is a key tool for defining the most appropriate strategies.

In this line, the concept is incorporated disaster risk management, adaptation and mitigation of climate change, sustainable production and consumption, biodiversity conservation, waste management, among others.

It is notorious the impulse that have been globally linked to the management of disaster risk issues and climate change, crystallized respectively in the Agreement Sendai in the first case and the Paris Agreement in the second, both of 2015, which all governments have undertaken concrete actions to strengthen resilience and reduce emissions of greenhouse gases. On the one hand, the impacts of extreme events affect the most vulnerable populations that need to be assisted and on the other, entails costs for loss and damage production, housing, infrastructure, vital goods and services, which by its magnitude impede progress towards a sustainable and inclusive development. Thus, the underlying idea is that economic and social costs of dealing with the impacts of climate change on vulnerable communities are an entity as to constitute a structural barrier to development.

As for production and sustainable consumption, UNEP (2008) argues that it has not been possible to account for the costs associated with patterns of consumption and production by the breadth indicators to be considered, and therefore, it has been impossible to size their costs associated inaction. However, are these modes of production and consumption which in turn have an impact, according to Stern (2006), in the case of climate change “could cost between 5 and 20% of global GDP”.

In terms of biodiversity conservation, inaction would have costs associated with the loss of this biodiversity, increasing environmental degradation and consequent needs restoration, remediation or other remedial actions. In turn, Arendar (2014) argues that there is loss of control of genetic resources and inability to receive fair compensation for their use, accentuating vulnerabilities, thereby preventing a “fair and equitable sharing of benefits”.


As for sustainable waste management, it has emerged the idea of circular economy, key in quantifying the costs of inaction in the 5 hierarchical levels of waste management concept: prevention, reduction, recycling, recovery and disposal. In this regard, UNEP (2015) states that “decide on the appropriate financing model for a particular situation provides a” toolbox “to serve as a basis for action.”

3. METHODOLOGY

According Seiford et al. (2002) data envelopment analysis (Data Envelopment Analysis, DEA) is a special case of deterministic models nonparametric border. These models do not require specifying a particular functional form of the border function; come from the field of operations research, since they are ultimately problems, generally linear mathematical programming. They were initiated by Farrell (1957) and later developed by Charnes et al. (1978) with yields constant returns to scale and extended by Banker et al. (1984) including Variable Returns to Scale.

The peculiarity of the DEA on any rate is that the weights used are endogenously determined by the measurement technique itself (Giralt & Castello, 2004). These weights are obtained, as the rate of efficiency by solving a linear programming model, the formulation shows the relative nature of the measure of the efficiency obtained. In fact the rate of efficiency provided by the DEA method is but the result of comparing the productive activity of each organization, evaluated with other technically homogeneous.

For these reasons, we consider this method as the most suitable for our study because it arises as an instrument of analysis of the relative efficiency of enterprises, enabling arrange according to their degree of efficiency and as a technique of benchmarking, which enables orientation internal and decision-making processes of the same policies.

By defining efficiency based Hua-Qing et al, (2015), who claim that it has two components: technical efficiency and allocative efficiency. These combine to give economic efficiency, because to achieve the minimum cost a company must use their inputs in the most efficient way (technical efficiency) and choose the combination of inputs correctly given the relative price of them (allocative efficiency). In turn, the authors apply the model in the circular economy to China in a 11-year plan.

Also, Giralt & Castello (2004) emphasize that efficiency is a relative concept, which acquires true meaning, if the result of an economic unit is compared to a standard. Therefore, the measure of efficiency is developed in two stages. In the first, a “frontier” function that indicates the maximum level of output that can be achieved is set. In the second stage the results obtained for each entity with standard border are compared, characterized as inefficient behavior deviations.

The production function is a representation of the possible combinations of inputs that generate a given level of production. It is considered that a production function represents all levels of outputs technically efficient than can be obtained from different combinations of inputs, in the sense that it is not possible to produce a given level of service with fewer inputs than those listed in the production function.

Ding et al. (2016) developed state that the DEA is an extreme and nonparametric method for estimating production frontiers and evaluation of the efficiency of a sample of production units (DMUs
or decision making units, in the usual terminology). According to these authors, the DEA has proven to be a powerful method for analyzing the efficiency of series production units in terms of inputs and multiple outputs. In this type of analysis the relative efficiency for each DMU is calculated by comparing its inputs and outputs with respect to all other DMUs. The DEA has been used primarily to analyze the efficiency of non-profit organization, where measures to quantify the benefits are particularly difficult to calculate, specifically in the public sector, and in recent years is being used in other sectors, a special reference to the world of financial institutions. The DEA belongs to the group of so-called frontier methods, in which production is evaluated for production functions, where for the production function means the maximum attainable level of output with a certain combination of inputs, or the minimum level of necessary inputs to produce a certain level of outputs.

In this study we used the variables GAMS software, general purpose, and constant returns to scale and increasing returns. Here, the model used is based on the simplex method OSL low GAMS. That is, it has built a database of GAMS with an external input format for the problem data (values of inputs and outputs) and an output format for analysis results. The results are not significantly different when the problem with each of the scheduled procedures (primal, dual, CRS, VRS and NIRS) is addressed.

In non-parametric models, the efficiency analysis does not require any assumptions about the production frontier, with the efficiency of a defined unit with respect to the “observed” best performing units. This analysis stops in identifying the “best behavior” rather than the “average behavior,” as does the regression analysis.

In addition to measuring the relative efficiency is obtained using an AED: 1. A, piecewise linear empirical envelope surface, which represents the best practice frontier. 2. An efficient to represent the measure of maximal for each DMU behavior as measured by its metric distance to the border. 3.

Specific objectives or projections on the efficient frontier for each inefficient DMU. 4. A set of efficient reference or peer group for each DMU, defined by the most efficient units next to it. It is observed that the reference assemblies or peer DMUs produce the same or greater level of outputs with equal or less inputs regarding inefficient DMU subject to comparison.

4. THE BENEFITS OF ACTION AND INACTION COSTS IN WASTE MANAGEMENT

Give an adequate response to waste management remains a global challenge and even more in developing countries. It requires data, which often are overshadowed by high rates of informality related to the activity. In turn, other factors, such as lack of institutional and technical capacities to adopt appropriate technologies are added.

According to UNEP (2015) the economic costs of not addressing the problems of waste management in developing countries are difficult to quantify, but the available evidence suggests that they think largely outweigh the financial costs of the environmentally sound management waste.

Minamata Convention on Mercury in 2013 therefore seeks “… to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds”. Notably, the
agreement negotiations were led and chaired by Uruguay and is the first environmental agreement to enter text in your topics linked to human health, with special focus on women and children. This agreement is strongly endorsed by the World Health Organization, and therefore enrolled in the conceptual framework for action and inaction that the organization carries out.

Thus, the costs of inaction enter the field of environmental economic studies, questioning the construction of new scenarios that take into account other components, such as territorial, environmental and health policies, or the expected changes in vulnerability and resilience of communities, depending on the desired future and the goals set by each of the countries.

According to UNEP (2015), globally, by 2012 more than 2,000 million people lacked access to solid waste collection and a population of over 3,000 million people had no access to controlled disposal sites. Collection inadequate or nonexistent, waste generates strong impacts on public health and the environment, with consequent social and economic costs.

In that perspective, is that the cost of inaction is a key component in the development of future scenarios: policies, in the progress that they present (designed, approved, being implemented, implemented, consolidated, assessed). This refers not only to environmental policies but also social and regional policies affecting vulnerable populations.

From the health costs with consequences on human health, gastrointestinal infections (diarrhea and gastroenteritis direct contact) arise; respiratory diseases, especially in children and dioxin poisoning linked to open burning of waste sky; spread of infectious and vector-borne diseases (which are exponentiated by clogged sewers absence of urban waste collection and this causes floods) diseases; risks of hazardous substances that enter the food chain.

A chapter apart are the impacts resulting from the absence of proper management of hazardous waste, ie those who because of their intrinsic hazard (toxic, corrosive, reactive, flammable, explosive, infectious, ecotoxic) can cause damage to health or the environment.

As an example, could be mentioned the case of lead contamination in the neighborhood of La Teja in 2001, due among other factors, the handling exposed battery by informal classifiers and the proximity of the population in Uruguay with inadequate disposal thereof. The impacts occur in the nervous, hematopoietic, urinary, gastrointestinal, renal, reproductive and endocrine system, affecting about 500 children. They led to the creation of special units of medical care, treatments that still persist in some cases and dozens of relocations, giving families new homes in environmentally controlled sites and soil remediation actions costly in the area.

According to the UNEP (2015) the cost of inaction for society is between 5 and 10 times the per capita financial cost representing a proper waste management. These costs focus on health care and lost productivity, as well as corrective and remedial actions necessary for both the hardware and for the people. In Table 2, they have been classified hierarchical levels of waste management. Inaction in each of the levels has economic, social and environmental different consequences, so this disaggregation allows also plan and weigh the actions.
For example, inaction in prevention, implies the need to increase costs in major operating components, to achieve proper management, such as the costs of labor, fuel, energy, maintenance and repair, emission control and monitoring, public communication, management and administration, among others.

Table 2. Hierarchy in waste management

<table>
<thead>
<tr>
<th>PREVENTION</th>
<th>REDUCTION - MINIMISATION</th>
<th>REUSE</th>
<th>RECYCLING</th>
<th>OTHER FORMS OF RECOVERY AND RECOVERY (INCLUDING THE GENERATION OF ENERGY FROM WASTE)</th>
<th>LANDFILL</th>
<th>CONTROLLED DISPOSAL</th>
<th>UNCONTROLLED DISPOSAL</th>
</tr>
</thead>
</table>

Source: Adapted from Global Waste Management Outlook (UNEP, 2015)

The application of the 3Rs reduce, reuse and recycle reduces the need for investment aimed at treatment and adequate facilities for waste disposal. In this line, has chosen a concept of inaction defined as the absence of action or inappropriate action on a broad concept, comprising as inadequate management, imbalances in the distribution of management responsibilities including economic, compared to generate waste and who take care of the damage.

5. WASTE MANAGEMENT IN URUGUAY: THERE ARE COSTS OF INACTION?

In Uruguay, as in other developing countries, particularly in Latin America, management of waste it must be treated by addressing its complexity, comprising environmental, socio-cultural, technological and economic, with a focus on labor informality that runs through all stages of the life cycle of waste.

Informality in waste management has its counterpart in the environmental and health urban conditions of people, so although at first glance some issues appear to refer to other fields of study and action, are closely related to waste management, as in the case of urban planning and land management.

In the case of Montevideo, notes that in 1995, in the city 404,684 annual tons of municipal solid waste, a figure which by 2014 had risen to 809,558 tons harvested annually. In almost the same period, the population living in Montevideo went from 1,382,537 in 1996 to 1,378,610 inhabitants. That is, while the population remained with minimal variation downward, waste collection doubled.

Moreover, IMM (2012) published the results of the waste classifiers population characterization of in the department, implemented by the Municipality of Montevideo, which involved surveys of classifiers to 1211 households located in settlements.
This study arises, among other things, that it is a younger population and are more numerous households not only in relation to the homes of Montevideo but also to households in squatter settlements that develop other activities, which groups more critics more than 50% are located within 500m of burning waste in the open sky, more than 58% to landfills, more than 40% to breeding pigs, around that percentage to toxic and more industries 10% to ground lead. That population also has a precarious condition of housing tenure, and comparatively lower levels of education than the average department. In turn, more than 80% collects hazardous waste. As stated in the report “Not only predominate building and habitability deficiencies, also the risk of collapse and flooding is greater in these cases and the high percentage of close to areas with high toxicity households particularly highlighted. As a result of these figures is verified greater exposure to health risk situations. “

With these indicators, in the long term, this population, particularly children, will require state assistance with impact on health and social services in response to the lag in their social inclusion, which also has an associated cost.

In line Jie Wu et al. (2016) and taking into account the finite resources available to local governments, strategic planning that takes into account the hierarchical order of Table 2 cobra significance. From this perspective it is necessary to invest in a cultural change that encourages people to provide support for policy advocacy reduction - minimization, reuse and recycling as well as generate applicable for the implementation of these policies legislation, with the postulate that “cleanest city is the least dirty and not cleaned more”.

Thus, bearing in mind the pecking order, investment in implementation of measures that promote the prevention and reduction in waste generation will have more impact in terms of cost - benefit if they operate at lower hierarchical levels. For example, issues that are under discussion as the collection of plastic bags in supermarkets or how it could impact costs; if you invest in collection vehicles arriving with higher volumes to existing open dumps.

Also, solutions for final disposal should incorporate the coordination and rationalization of resources between different levels of government (national and sub-national) to streamline efforts, reduce management costs and implement appropriate technologies according to the volumes produced beyond administrative political divisions.

5.2 Towards a national sustainable waste management system

In 2010, the Uruguayan government convened a national dialogue to develop a comprehensive approach to the creation of a National System for Waste Management, taking into account the limited use of waste strategies for recovery, waste mostly non they are classified at the origin.
Management divided by administrative boundaries of departments as shown in Table 1 given harvest volumes, impossible to define 19 individual solutions with economic and financial feasibility for better environmental management and modernization process, formalization, utilization and recovery of waste. For example, it is necessary to take into account the volumes of waste that make operational and profitable energy recovery plant and if these volumes are produced in a single department or is necessary to centralize the production of several of them.

In 2012, from a Data Room diagnosis was made with the private sector, to achieve the most appropriate national solution. Of this call, they participated 53 companies interested in providing solutions for the recovery and disposal of waste (terms identified in Table 2. Hierarchy of resource management). As a result, agreement on the need to regionalize and act as a country was reached.

Table 1. Departmental Division in Uruguay

![Departmental Division in Uruguay](source: www.presidencia.gub.uy)

Evaluate the best proposal involves not only think about the cost of installing infrastructure, technology and other decisions choose, but take into the equation the cost of inaction. This consideration should include the impact of regulations, expectations of developing legal frameworks, policies, processes implementation of existing policies, labor standards and housing applied to families of classifiers, spending on health, soil remediation quality of water resources, etc. An example of this would be to consider the policy of relocation which was reflected in the National Resettlement Plan of families in flood-prone and polluted areas that was part of the National Housing Plan 2010-2014 and therefore was expressed with force of law in the national budget and departmental budgets.
5.3 Analysis of the efficiency of waste management department

This methodology and procedures have been applied to DEA different departments identified in Table 1, in order to obtain a measure of relative efficiency thereof. In this type of analysis, one of the main problems is the determination of inputs and outputs for analysis. The activities required for the management of waste generated in each department are analyzed.

Thus, it has been used as the waste generated input variable, since it is a proxy for the level of importance of the activity, the provision or infrastructure and other resources for processing and collection. In addition it is one of the most significant variables of the structure for the operation. They have been chosen as output variables representative volume of activity, i.e., we used the variables: amount collected (tonnes), the type of organic waste, glass, plastics, paper. In our opinion, this is a variable that also represent the different types of waste generated although there is a growing practice towards recycling and sorting household.

As noted above, they have been excluded from the economic and financial aspects by the bias of the implementation of centralized rates that do not meet the cost structures of the different departments, and that in most cases distort the results. Services are provided to the population and collected through fees collected by each departmental management.

With these inputs and outputs, we proceeded to build a DEA model that allows us to measure the relative efficiency of the activity. This type of analysis has been performed for all departments in Uruguay and during the two years 2012 and 2013 are analyzed in order to avoid distorting the study of a single year would result in the event that any department that year it would have been important “shock” in some sense.

One of the advantages of DEA is able to order units high to low efficiency, although the numerical results can vary slightly depending on the method used, because we must not forget that this is an average approximate, and therefore the resulting management can be debatable. Therefore, we have merely indicated three groups departmental waste management: very efficient, efficient and inefficient, without introducing quantitative values as we consider in this paper have special relevance. We must not forget that this is an arrangement on the basis of inputs and outputs defined, and not as a sort on overall efficiency in waste management. With regard to the above, the classification is presented in Table 3, and within alphabetical order.
6. Conclusion

We understand that this study has allowed us to know and question concepts that had not yet been analyzed in waste management in Uruguay. It is the starting point for an extensive study using the DEA or other quantitative analysis methods. This introduces the main limitation given the limited availability of data to effectively assess the costs of inaction. In parallel, we have tried to analyze how they impact the costs of inaction and contextual factors in waste management.

Also, there are no protocols for validation of data, which may have comparability restrictions. The data are mostly generated in the perspective of reaction and action, and not from inaction. This change would involve prioritizing data generation to build other indicators and analyze them together with a holistic view of the issue, because it is a more complex mesh that includes a network of action toward a desired future.

That vision, as well as incorporating new indicators, should also include the construction of scenarios from environmental policies and urban planning (including cleaning of cities and waste collection), health policy, social development, among others, each with appropriate weighting, to the assessment of a complex object of study. That complexity is related to its dynamic nature (cities change their morphology and area, and accordingly, the population changes). The information, or its absence, is correlative of political constraints, institutional, legal and technical; conscious and unconscious decisions.

As an example, a more complex model could reveal future costs in the present have no greater display. In the case of the Department of Florida, according to the results of DEA applied, it was classified as very efficient management. This department, from 2008, as part of a pilot plan (along with Montevideo) in accordance with the classifiers generated micro, clean circuits, formal working conditions for workers in collection and classification, with proper distribution of clothing for execution of that work, a part of the city. With the same classification figure the department of Durazno. In this department, the site of final disposal of waste is 3.5 km from the city. While improvements have been made in the internal infrastructure, population settled there a very short distance which also generates adolescent work informally linked to the proximity of the resort.
In this line, if we incorporate contextual information not covered in the variables included in the DEA model, we found that the results are not consistent with the operations actually performed in each department. Therefore, we identified an opportunity to improve the definition of variables in a future study. Although the model has developed results do not appear to be consistent with reality.

In a future analysis should be considered health costs and state assistance to vulnerable groups. This population is liable to be affected as a result of direct or indirect transfers. They could be linked to the classification, to be located in environmentally fragile sites because of its proximity to uncontrolled landfills, or working conditions with inadequate waste.

In turn, contemplate the costs of growth of the city without planning. This implies transported elsewhere-the necessary sites for waste disposal or populations located near them. Together, take into account the potential benefits forgone by absence of actions that add value in considering waste as a resource, whether by recycling, power generation or reuse of each type of waste.

Thus, they could build various future scenarios and compare the baseline scenario and possible scenarios under decision making (such as land-use planning, policy on the axis of production and consumption, labor formalization and other social policies).

Finally, we understand that many of the variables to be analyzed must incorporate the cost of inaction in its determination, because otherwise could not be used in a planning analysis. Analyze the cost of inaction is key decisions need to be taken to advance its implementation.

On the other hand, in developed countries it is applying the model of the circular economy, linked to the life cycle of waste. It would be useful to deepen the applicability or not of this model in developing countries and the adjustments that could be made to him if feasible even partially, its applicability.

In this paper, we discussed the theoretical body of our work in progress and first preliminary results with the identified variables. We understand it is a first step and that there is a vast line of research to develop and work empirically.
7. REFERENCES


Deployment Platform Bim Budget

Vinícius De Lima Queiroz

ABSTRACT

To ensure that projection methods, ownership and control of the cost required to perform the services that make up a work or a project are necessary numerous information. Information on resources are critical to control of the project. Preparing a budget is a task of great responsibility and importance, the budget determines the viability of an enterprise and is an estimated parameter, then budget the costs related to direct costs and indirect costs. Direct costs are the costs of raw materials, labor and equipment, and indirect costs are administrative, financial and tax expenses. This paper discusses methods of deploying BIM budgets, which are used to perform the quantification process throughout the project life cycle. In these circumstances, the use of BIM - Building Information Modeling can perform automatic quantification and precise and hence reduce the error margin in budgeting thus increasing its speed, allowing exploration of more design information, enabling greater visibility for the control of actions in the design of the resources necessary to perform the work.

Keywords: Budget; quantification; BIM; Lifting quantitative.

1. INTRODUCTION

Each and every enterprise depends on many details and in many ways, among them are the projects, budget and planning. The construction projects rely on an exchange of information with designers, architects, engineers and estimators. For the detailed budget for the project is required a variety of information extracted from the project, which should be presented in a cost spreadsheet necessarily along with the quantity of services. Given the new dimensions of the market and the globalization guidelines, there is a need to master with security the cost of the project. Cost that this requires a methodology able to generate quality information and reliable, in time for decision making.

The most recurrent errors developments are poorly designed projects and are considered one of the main problems of management of works. According to Article 7 of Law 8666 of June 1993 for the execution of
works and provision of engineering services shall comply with the provisions of this Article and in particular the following sequence: I basic design; II executive project; III the works and services, § 2 The works can be performed only when: I there is a detailed budget worksheets to express the composition of all its unit costs. budget errors due to the bad projects may have the systematic occurrence of excessive additives with quantitative reflecting overpricing. Thus emerges the need for logic for the preparation and organization of budget information.

The main objective of the budget is to capture accurately the cost data required in project design and avoid the risk of a budget overrun in construction. With the implementation of the BIM model, we expect a accuracy of cost estimates obtained with the automatic identification of construction components, the accuracy of the cost is related to the level of detail and quality of information projects. Changes can be made in the design phase, any change automatically results in quantifying without compromising the performance of the work, perform projections and simulations to facilitate decision making.

The organization BIM platform has an exact precision of the design of the survey obtained by identifying the services in automatic mode, with the automation of calculations made possible costs by BIM should reduce the time to complete the survey of quantitative and expand the level of detail and accuracy of budgeting actions. The approach to the subject explains that the project is built virtually, before actual construction, building components and matching all involved in a virtual environment of cooperative project, ensuring that the aggregate knowledge of each professional is integrated into a single data source.

2. IMPLEMENTATION PHASE

DIMENSIONS

BIM has several layers of information as known dimensions. A model can be 2D, 3D, 4D, 5D, 6D, 7D, 8D. We can classify the main dimensions of BIM as:

- 2D graphic - are plan dimensions, which are graphically represented the plants of the enterprise.
- 3D Model - adds a spatial dimension to the plane, where you can view the objects dynamically. A 3D model can be used to view in perspective of an enterprise in prefabrication parts, lighting simulations.
- 4D Planning - add the time dimension to the model, defining when each element is purchased, stored, prepared, installed, used. It also organizes the layout of the construction site, the maintenance and operation of the teams, the equipment used and other aspects that are chronologically related.
- 5D budget - adds dimension to the cost model, determining how much each part of the work will cost, the allocation of resources to each phase of the project and its impact on the budget, the control of the work goals according to the costs.
6D Sustainability - adds dimension to the energy model, quantifying and qualifying the energy used in construction, the energy to be consumed in its life cycle and its cost, in parallel to the 5th dimension. The energy in this case, can be directly related to the physical impact of the project on the environment in which it is inserted.

7D Facilities Management - adds the dimension of the operation model, where the end user can extract information on how the enterprise as a whole works, its peculiarities, which maintenance procedures in the event of faults or defects.

(MATTOS, PINI-Dec-2014)

3. WORKING STRUCTURE

- Dimension - 5D Budget
- virtual building design
- Lists in Excel
- Access to system integration
- finishes settings
- automatic budgeting
- Percentages running
- Import program

Source: Author
The aim set forth in this work aims at the implementation of BIM platform in budgets for this is the dimension - 5D budget.

**BIM Tools in Budget**

The importance of the quantitative survey of project services provides the starting point for the overall assessment of the role of cost management within one project team (MATIPA, 2008).

**BIM 5D**

For many estimators, the ability to extract data, quantitative and associate survey using MS Excel spreadsheets is usually sufficient. The estimator is able to use rules to calculate the quantities of these items based on the component properties or manually enter the data not extracted from the model. As a result, all information needed to develop a full cost estimate and detailed list of basic activities can be used for planning the construction. If this information is related to the BIM components (EASTMAN et al., 2008).

The main advantage of the 5D modeling (modeling + time + costs) for the builders is increased precision during construction, with less waste of time, materials and reduction of changes during the execution of works so you can control the critical activities that overlap during the execution, understand the final design through virtual image and there is a better balance of products (AZEVEDO, 2009).

**3.1.2 Virtual Building Design**

![Figure 1 - Building Virtual](image-url)
The project creates a virtual building that allows viewing and identification of each "section" of the work (such as walls, openings, windows, etc.). By clicking on each item, the data area, volume, thickness, and other details are not able to be extracted because of the technology in three dimensions.

3.1.2 LIST

![Figure 2 - The List Excel](image)

The program lists directly to Excel project information for rooms, such as flooring, room name, number, floor area, perimeter, and ceilings. In addition to this list, the software also creates other files in Excel that will be used in the integration of the design and budget. They are: frames list; list of hydro-sanitary equipment; Masonry list and list of toppings.

3.1.2 ACCESS TO THE INTEGRATION SYSTEM

![Figure 3 - Integration System](image)
By accessing the integration system, the user will choose the reference state prices for which will be sent the budget and also provide the name of the project and run the project.

3.1.2 DEFINITIONS OF FINISHING

The software then prompts you to open the file generated by the program to the list of rooms. Each room is presented to the floor finishes are defined, wall, baseboard and ceiling, plus the amounts of light points, sockets, switches and points phone. Although the choice of finishes are quite simple (just click on the chosen finish the displayed list), the system displays finishing standards depending on the type of room. If the room is a bathroom, for example, for wall covering system automatically displays the tile option. However, if the user changes the coating to ceramic, the bathroom next item already present, as an option, this coating to the wall.
3.1.2 BUDGETING

After the import of the rooms, the system prompts you to open the file with the frames generated by the program. Each casing is provided, allowing choice of material from which it is made (wood, PVC, aluminum, iron etc.), the type of glass (if any) and the type of threshold or sill. In a process similar to the routines described above, will also be imported files with the list of hydro-sanitary equipment, masonry list and the list of toppings. At the end of this step, the budget will be automatically generated.

3.1.2 PERCENTAGES

Figure 5 - Budget

Figure 6 - Percentage To Be Performed
The budget ready and Excel spreadsheet contains several folders with the schedule already prepared to receive the percentages to run monthly, calculating thus: Monthly and cumulative totals or only material values or hand labor; ABC curve of services, which will be listed services in order of decreasing importance in the enterprise; the miter map; the list of rooms with their respective finishes, among other items.

3.1.2 IMPORT

![Image of spreadsheet]

**Figure 7 - Imports**

The estimator that want to improve the budget can import the data into one budget software, engineering, procurement and control works with structured database. With one click the worksheet is created.

Source: (Bernardo Corrêa Neto, gerente de Engenharia e Custos da PINI – 2009).

3.1 COMPARISON

Quantitative surveys the is traditionally held from the project analysis developed, the technical specifications and construction plans in 2D. This method can often present itself flawed and inaccurate, often affecting the decision-making enterprises and increasing the chance of errors and deviations in the budgeting process. Therefore, this paper analyzes the use of a BIM software can improve the quantitative assessment process, using a model 5D applied in the construction of buildings, which consists of computational visualization of work and their quantitative.

To Mattos (2006), this is a phase that requires more intellectually estimator, requiring the same project of reading scores, area calculations, volumes and lengths, engineering tables query, conversions, among others. In the model currently adopted by most companies, the professional luff the work draws dimensions of length and project areas that represent the three-dimensional reality of work in a two-dimensional plane. These manual measurements have errors and are extremely inefficient; the greater the work in question, the greater the error introduced due to propagation.
With BIM projects will inevitably be more detailed, not only because of the information related to the model as well as the automation of its elements, contributing to the elimination of the causes for the shortage of project details and errors and omissions (legislation) (VASCONCELOS, 2010).

Arguably, the use of BIM to support construction management can reduce the waste of materials at the construction site. Better management of materials and programming works by eliminating errors in the survey of quantitative and schedules more accurate works. (CLAYTON et al., 2008).

4. CONSIDERATIONS

The development of this final project sought information in the implementation phase and the use of BIM budgets.

From analysis was possible to see, based on theoretical frameworks, the margin of error of the estimates is proportional to the development of the project. On the results, it is understood that, from the use of BIM, you can improve the budget and control projects costs. The use of BIM can generate an automatic quantification and precise budgets, minimizing the burden of budgeting activity and reducing errors. With BIM tools, to modify the design in 3D, all drawings and documents are updated and, likewise, the quantitative are recalculated. (BRAGA, 2015)

Estimators must understand how BIM can support specific budgeting tasks, reducing errors and improving the accuracy and reliability of the budget. More importantly, they can benefit from the ability to quickly respond to changes during the crucial stages of the project, a challenge that many estimators face daily.

Finally, the objective is to compare the reductions in margins of error, the survey of traditional quantitative, the benefits and results in an application of BIM tool in quantitative assessment process of a work. With this, identify the advantages of the application of BIM in the budget of an enterprise, assessing the accuracy and reliability of quantitative obtained through the tool.

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Performance assessment and cost analysis of a photovoltaic system located in Curitiba – Brazil

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ABSTRACT

In the urban environment, On Grid Photovoltaic System has great application as electricity generators at the point of consumption. Usually, their integration is easy to apply to the building and does not require additional area for the installation of photovoltaic panels, as they are installed on the roof of the building. The Photovoltaic Systems, have high reliability, they operate is cleanly, quietly and safely due to the current technology, and intensely reduce the cost of power purchased from the utility. The evaluated local, it is a company in the metal industry concerned with sustainability and respect for the environment, in Curitiba - PR. The company has more than 120,000 m² building area and more than 1,600,000.00 m² of total area, began the pilot photovoltaic project on an office area besides sustainability practices. This small pilot system already installed behind much evidence of a new form of sustainability and respect for the environment. In this paper, we evaluated the performance and economic viability part listed by calculating the avoided cost in the period in operation. Verification of the performance of a Photovoltaic System, mainly through some indexes known as merit indexes, which are: Yield; Performance ratio; and capacity factor. The power generation is not in line with the expected values and the indices obtained for the Photovoltaic System evaluated in Curitiba and are suggested some checks to improve performance, however, the system resulted in a large reduction in the cost of purchased power.

Keywords: Photovoltaic Solar Energy, Sustainability, Economic Viability

1 INTRODUCTION

When we look at the last two years, we see a considerable growth of the photovoltaic power generation industry worldwide. The 2014 to 2015 Brazil caught a glimpse robust growth, by increasing your potential to generate 15 MW to 40 MW. Still, until the end of 2016, the installed capacity should achieving 150 MW
(Ramos, 2016).

At viewpoint of sustainable and renewable, solar energy is presented as one of the best options. Besides this advantage, Boyle (2004) cites as technical and economic benefit the fact that power generation be decentralized, reducing maintenance costs and reducing losses in transmission and distribution.

Since it entered into force the ANEEL Resolution No. 482/2012, on April 17, 2012, Brazilian consumers can generate their own electricity from renewable sources or qualified cogeneration and even provide the surplus to the distribution network of its location (ANEEL, 2016).

Much of the increase in the generation of photovoltaic energy due to the distributed generation, where small systems relieve the owner spent after the start of system operation. Not only residences are seeking this alternative, as well as small, medium and large companies.

According to Jakubiak and Marchiori (2016), one of the great challenges of the photovoltaic industry is to design cells that have a relatively high generation efficiency. Today on the market is hard to find solar modules that have higher efficiency of 19%. Once the technology above this deficiency, will be needed smaller area for greater power generation. Cells with higher efficiencies result in systems with better performance.

According Urbanetz Jr (2010), in Brazil, is not yet a widespread technology, many problems related to energy availability are not reported, it is useful to monitor the particular photovoltaic system to meet their actual performance.

To check the performance of an installation are taken into consideration some indicators, called Merit Indices, these being: Yield, Capacity Factor and Performance Ratio. By considering these indices, it is possible to compare systems from different facilities; it is possible to evaluate the performance estimate the optimization of each facility (Benedito, 2009).

The aim of this work is to use the indicators of Merit Indices to evaluate the performance of a on grid photovoltaic system located in the municipality of Curitiba and realize the economic viability study of the system.

2 MATERIALS AND MÉTHODS

2.1 Photovoltaic System Reviewed

The photovoltaic system evaluated, it is a Grid-Connected Photovoltaic System and is installed on a company's metallurgical branch located in the city of Curitiba - PR. The system has been in operation since August 2013, however, in this article, was evaluated twelve months, from March 2015 to February 2016.
2.2 Grid-Connected Photovoltaic System - GCPV

Basically, a GCPV is composed of a photovoltaic panel, which converts the sun’s energy into electrical energy in direct current (DC) and an inverter which converts direct current into alternating current (AC) with compatible voltage and frequency with the grid of the utility to which the system is interconnected. This type of system has the following advantages: high productivity; no batteries and automatic shutdown bank in case of mains power failure, preventing the islanding phenomenon (Urbanetz Jr, 2010).

The GCPV evaluated has an installed capacity of 6.9kWp (30 WSolar modules of monocrystalline silicon technology, YZM230M-60 model, divided into two series of 15 modules connected in parallel) and a single-phase inverter 220V rated power of 7.5kW (SMA Sunny Mini Central 7000HV model). Figure 1 illustrates the installed photovoltaic panels and in Figure 2, the inverter and junction box.

Figure 1 Photovoltaic system reviewed.
Performance GCPV Reviewed

The analysis of evaluated GCPV performance is based on the energy values generated for twelve months of operation and irradiation values (average of ten years) incident on the photovoltaic panel, obtained by the Solar Energy Brazilian Atlas (Pereira et al, 2006).

From the generated energy and the incident radiation, the GCPV merit indices in analysis are presented, these indices are: Yield (productivity), Performance Ratio (performance rate) and Capacity Factor. The evaluation period is from March 2015 to February 2016.

Through the data, it is possible to perform an analysis of economic feasibility, obtaining the payback time of the investment. With energy data generated by the system, it is possible to estimate the avoided cost of purchasing electricity for two scenarios: with and without taxing the state tax.

3 RESULTS AND DISCUSSION

3.1 Energy Generated by GCPV Reviewed

From March 2015 to February 2016, the evaluated system (twelve months) generated 8.4MWh/year.

The power generation is proportional to the incident radiation in the photovoltaic panel, so, in the summer months (more sunlight) will generate more electricity and in the winter months (less sunlight) will lower generation (Urbanetz Jr, 2012). Table 1 shows the values of energy generated in each month of
operation, and Table 2 the average daily energy in each operating system month evaluated.

**Table 1** Energy generated in each operation month evaluated system.

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<td>647.7</td>
<td>651.8</td>
<td>588.1</td>
<td>614.0</td>
<td>580.5</td>
<td>826.8</td>
<td>796.7</td>
<td>823.4</td>
<td>628.5</td>
<td>683.3</td>
<td>868.4</td>
<td>696.7</td>
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**Table 2** Average daily energy generated in each operation month evaluated system.

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<tr>
<td>20.89</td>
<td>21.73</td>
<td>18.97</td>
<td>20.47</td>
<td>18.73</td>
<td>26.67</td>
<td>26.56</td>
<td>26.56</td>
<td>20.95</td>
<td>22.04</td>
<td>28.01</td>
<td>24.02</td>
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</table>

Figure 3 shows the energy generated every month of operation of the PV system evaluated.

**Figure 3** Energy generated each month of operation.
Figure 4 shows the energy generated in twelve months of operation the evaluated PV.

**Figure 4** Energy generated in twelve months of operation.

### 3.2 Incident Irradiation in Photovoltaic Panel System Reviewed

The irradiation values incident on the photovoltaic panel system evaluated as a basis for the calculation of some of the photovoltaic system merit indices were obtained from the SWERA Project database (Solar and Wind Energy Resources Assessment). From that database are available solar radiation maps of the entire Brazilian territory (Pereira et al, 2006). The irradiation values provided by SWERA design, or refer to the horizontal plane or inclined plane equal to the local latitude. Aiming to favor the average annual irradiation, the photovoltaic modules GCPV were installed with an inclination of approximately 25° and azimuth without deviation from the geographic North.

The evaluated GCPV is located at the following coordinates: latitude -25.27° and -49.21° longitude. As the SWERA Project provides points of 10 in 10km, was identified the closest point to the installed system, which is the following coordinates: latitude -25.24° and -49.21° longitude, this point is about 6.4km from the installed system, so these will be the irradiation values in the PV panel plan effectively installed.

Table 3 presents the average daily irradiation values on the slope for each month of the year to the point mentioned.
Table 3 Average daily irradiation on the inclined plane provided by SWERA Project.

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<th>Jan</th>
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<tr>
<td>5.18</td>
<td>5.37</td>
<td>5.61</td>
<td>4.96</td>
<td>4.51</td>
<td>4.44</td>
<td>4.36</td>
<td>5.30</td>
<td>4.93</td>
<td>5.05</td>
<td>5.45</td>
<td>5.24</td>
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$kWh/m^2 \times day$

Figure 5 shows the incident irradiance values in the plane of the photovoltaic panel system evaluated (provided by SWERA Project).

Figure 5 Irradiation incident photovoltaic panel plan evaluated system.
3.3 Merit Indices of GCPV Evaluated System

The merit indices are used to compare PV systems operation located in different places and with different power ratings (Oliveira, 2002; Benedito 2009; Marion et al, 2005).

3.3.1 YIELD

It is the relation between the generated energy (kWh) and installed PV power (kWp), usually tied to one year of operation, annual yield, but can also be considered the monthly yield (Table 4). Equation 1 shows the quantity in question.

\[
Y = \frac{\text{Generated Energy (kWh)}}{\text{PV Power (kWp)}}
\]  

(1)

**Table 4 Monthly Yield of evaluated GCPV.**

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<tbody>
<tr>
<td>93,87</td>
<td>94,46</td>
<td>85,23</td>
<td>88,99</td>
<td>84,1</td>
<td>119,83</td>
<td>115,47</td>
<td>119,33</td>
<td>91,09</td>
<td>99,02</td>
<td>125,8</td>
<td>100,9</td>
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</table>

Analyzing the monthly Yield of GCPV evaluated in the twelve-month period, the annual productivity was 1218,24 kWh/kWp.

3.3.2 Performance Ratio

It is the relation between yield (kWh / kWp) and the number of hours of sunshine to 1000W / m² (h) incidents in the PV panel, also usually linked to a year of operation, annual performance ratio, however, can also be considered monthly performance ratio (Table 5). This quantity is expressed in percentage. Equation 2 shows the quantity in question.

\[
PR = \frac{\text{Yield}}{\text{Irradiation/1000}}(\%)
\]  

(2)
The monthly rate of performance values over the twelve months of operation GCPV evaluated show an average annual performance rate of 66.22%.

### 3.3.3 Capacity Factor

It is their real ability to generate power due to the energy it would generate if it operated at rated power for 24 hours a day, also expressed as a percentage (OLIVEIRA, 2002). Equation 3 shows the quantity in question.

\[
FC = \frac{Gnerated\ Energy}{PV\ Power \times 24 \times days} \times 100\%
\]

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Monthly Factor Capacity of evaluated GCPV.</th>
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<tr>
<td>Mar/15</td>
<td>12,62</td>
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<td>Apr/15</td>
<td>13,12</td>
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<tr>
<td>May/15</td>
<td>11,46</td>
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<td>Jun/15</td>
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<td>Jul/15</td>
<td>11,3</td>
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<td>Aug/15</td>
<td>16,11</td>
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<td>Sep/15</td>
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<td>Oct/15</td>
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<tr>
<td>Nov/15</td>
<td>12,65</td>
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<td>Dec/15</td>
<td>13,31</td>
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<tr>
<td>Jan/16</td>
<td>16,92</td>
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<td>Feb/16</td>
<td>14,51</td>
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The amounts of the monthly Capacity Factor (Table 6) obtained during the twelve months of operation of GCPV evaluated show an average annual Capacity Factor of 13.87%. According to Benedito (2009), typical values for this technology is between 13% to 18%, confirming a good income to the evaluated system.

### 3.3.4 General Evaluation of the Merit Indices

You can compare the merits of indices obtained in this work with other results in the same municipality by other authors. Figure 6 shows a comparison of results Fusano (2013), Urbanetz Jr and Casagrande Jr. (2012) with those obtained in this work.
The Merit Indices when compared to the literature show a consistency in the results. The closeness of the results show that the system has promised efficiency.

Still one should take into account the (small) average irradiance variation that each system was exposed when measured. Fusano (2013) scores a radiation of 4.32 kWh/day, Urbanetz Jr and Casagrande Jr (2012) showed an average radiation of 4.95 kWh/day and this work was measured average radiation of 4.66 kWh/day. This difference in radiation may be responsible for the difference in the results presented in Figure 6.

Some points of the initial project could be further enhanced in order to improve merit indices, due to the fact that it was detected some flaws in the project design. Still, the values show the expected feasible.

### 3.4 Payback

For the design of the PV system was made an initial investment, shown in Table 7. The initial investment included the acquisition of 30 modules, 1 inverter, wiring, mounting bracket and installation.
The initial investment cost was R$ 38,850.00 reais.

Investment return comes month after month, as the power generation occurs, the cost avoided by the utility power purchase guarantees the savings in expenses that until now were inevitable.

Some Brazilian states have already joined the compensation of the full amount of the energy generated, in this way, for each kWh inserted into the network, the system provides you with a regulated amount of credit by ANEEL more tax increases.

To illustrate the payback time this work was taken into account the two scenarios, the compensation with and without incidence of taxes. Thus, the compensation kWh without tax provides a credit of R$ 0.42147, with tax return value is R$ 0.64543 per kWh.

In Figure 7, you can view the monthly returns for the two aforementioned scenarios.
As soon that the concessionaire pays the amount with tax increase on energy that the producer provides the network, it is clear that the payback is less.

The system evaluated is located in the state of Paraná, where there are no offsetting tax incidence (worst scenario), thus, the payback for the project is nearly 11 years. If the system was located in a state where there was a return to the incidence of taxes, the payback would be 7 years and 2 months.

This difference of 4 more years to payback is essential for new investors, the shorter the time, the more attractive it will be.

However, it can be said that the investment is safe and guaranteed return, as the solar modules have a service life of 20 years, and even after this period continue to generate energy (with a decrease in efficiency).

4 CONCLUSIONS

The company's GCPV analyzed in Curitiba - PR, during the twelve months of this operation generated 8,4MWh/year, with an average of 700 kWh/month.

In a few months the years 2015 and 2016 (spring and summer), the system generated more than 800kWh/month, however, it is observed in Figure 3 than in other months, too lowered his generation, even in the summer period.

As for the Merit Indices: Yield, Performance Ratio and Capacity Factor, some values are below those disclosed by other plants that develop research with GCPV.

The performance ratio was above 70% (understood as a good value) in just four months, resulting in an annual average of 66.22%. The capacity factor resulted in a value of 13.87% as good for this type of installation, but doable improvement.

The payback proved attractive (considering the useful life of the modules 20 years), with almost 11 years in the worst scenario and 7 years and 2 months for the best hypothesis.

The system resulted in a large reduction in the cost of purchased power.

They were observed in the installation (on-site) divergences that may suggest losses by heating too and physical damage of modules due to lack of space between them, evidence of any deformation in the fastening structure, there may be shadows at any time of day or season the year due to the layout of the modules, the inverter installation (maximum power voltage of the modules) may not have been respected and carried out the highest inverter efficiency range, among other points that were not the subject of this article.

It is suggested a review of the system for better use of the photovoltaic potential of the evaluated system.
5 AGRADECIMENTOS

The authors thank the SENAI - PR by supporting research and the company originator of the data.

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Tool Analysis of Economic Feasibility for Work in Individual Carrying Passengers for Ride Paid
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ABSTRACT

Schedule predictability is a recurring topic in many project monitoring and control situations, as it impacts in costs and quality. In an owner’s perspective, the cost and price dichotomy strengthens trend analysis methods based on physical progress. In this scenario, this paper aims to provide a method that identifies and speeds up eventual action plans, improving decision processes.

There are different methods to measure schedule accuracy and performance. However, Earned Value Management System (EVMS, also known as EVM), despite being originally developed as a cost management tool, is the most common one. Developed as a derivative method, Earned Schedule Management decouples schedule and cost performance measures, utilizing duration and physical progress as the main inputs. Therefore, this paper unfolds and details the application of the Earned Schedule Method.

The method is applicable at any project level, based on a schedule performance index in order to create an updated schedule, generating a new critical path, finish dates and physical progress trend curves based on actual performance. This detailing allows the project manager a drill down analysis, who is able to proceed more accurately and better measure action plans results.

The results indicate that not taking actions on identified deviation ends up on schedule impacts according to calculated trend. Also, the method application must be included in the project manager’s meeting schedule and identified highlights must be addressed, as well as follow-ups performed on the field. Additionally, the analysis routine points to opportunities of gains arising from its automation.

The method is primarily applicable on Primavera P6, but may also be used on other project management software.

Trend analysis based on physical progress is a reasonable solution by the owner’s perspective since there are traceable and trustworthy data for analysis. The method provides the actual performance of several ongoing processes (design, procurement, assembly, commissioning) and a more accurate date for future deliverables as long as the performance remains the same until the project’s end. While, the updated
schedule should be used to complement deviation and risk analysis.

**Keywords:** predictability, trend, physical progress, earned schedule.

**1 INTRODUCTION**

The unemployment rate in the six metropolitan areas (Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo and Porto Alegre) was 5.3% in 2015, and the estimated for the 2016 is 8.2% to the population economically active. According to the Brazilian Institute of Geography and Statistics (IBGE, 2016) the profile of the unemployed is represented by Brazilian adults between 25 and 49 years with at least high school, has previous professional experience and waiting up to six months to replace the market.

Therefore, since the formal labor market is low absorption (IBGE, 2016), or even shrinkage, occurs the migration of unemployed to entrepreneurship (Global Entrepreneurship Monitor, 2009). The transport sector by constantly being in the media and to allow low investment is one of the sectors that allows the perception of the opportunity to undertake. The individual passenger through paid ride does not require high qualifications, the opportunity is immediate, there is demand for professionals and can be a lucrative business (SOUZA, 2016). So, like all areas of an enterprise should consider the risks involved.

Due to the recent operation in the Brazilian market, many cities do not have specific legislation for the individual passenger transport paid ride. Moreover, competition from a traditional individual passenger transport market had immediate reaction demonstrated by protests against the legalization of applications used to perform the transport paid ride (OLMOS; FAVERA, 2015).

Despite the obstacles previously mentioned, the necessity proceeds make the workers face the challenge of growing into the passenger market. Therefore, we reaffirm the importance of the spread of information, work and easy to use and assimilation tools, showing the assertive way in making decisions to allow new entrepreneurs to invest in their careers.

Finally, despite the current uncertainties it is believed that as in so many other examples in history, as the impact of TV creation on the radio, the plane on ships and the internet about libraries, application of technology already allows creating new market segments that will be consumed by specific niches. As business reply traditional means suit the new market reality, because there is no economic factor warranting prohibition of new passenger private transport service providers (ESTEVES, 2015).

The objective of this work is to develop a tool model for analysis of economic feasibility, through traditional theories of investment, focusing on the Discounted Cash Flow. Chapter two reviews the literature on individual passenger transport (IPT) and technology initiatives that changed this business model. Chapter 3 contains the methodology for the development tool for decision making of the entrepreneur, as traditional theories of investment. The article continues with the application of the model in a case study, conclusions and references.
2 REVISION OF LITERATURE

Competition between old and new companies, with different forms of delivery of existing products and services, cause nuisance in veteran companies (PEREIRA, LAMB, 2015). Many veteran companies are not willing to change their way of delivering your products and or renew the business model to adapt to new technologies (GUTIERREZ, 2015).

According to Gutiérrez (2005) traditional businesses are seen by the government as a key economic structures and these companies are responsible for the generation of employment and income for the country. The Brazilian government try to raise barriers to economic protectionism to defend traditional businesses because they believe them to generate income in the country (LEAL, TASSIGNY, 2015). However, the acceptance of a new service or product in the domestic market depends on the user adaptation and the market need to meet a need (AVENI, FIACO, GOIS, 2016).

For Gomes and Romao (2012) to the companies to stay alive within the innovation market need to think dynamically with fast approaches, better and cheaper applications for the delivery of its products and services. Armas, Taño and Rodriguez (2014) show how the Airbnb is an example of disruptive business and demanded the hotel market changes in order to sell their services to competition. Airbnb offers service announcement for users offer rooms in their homes and are paid for it.

Even without own room and with less than a hundred employees, Airbnb was able in 2015 to reach a valuation of 25.5 billion as one of the largest hotel chains, the Marriott network, arrived in the same year at a valuation of 20.9 billion and thousands of own rooms and employees (BARBASCHOW, 2015). To compete with the services offered by Airbnb hotel chains are adapting their services to make sure their guests have the feeling of being at home, and best loyalty deals and partnerships with other service providers that add value to the core business (ARMAS, TAÑO, RODRIGUES, 2014).

For Lee and Vonortas (2004) the correct use of the term to designate which business disruptive companies that deliver differentiated products and services and competitive impacts the way to validate traditional and new business models. Companies with your media (applications) to delivery services like Uber, Netflix and Facebook caused a disruption in the traditional models for individual transport passenger, streaming video and social interaction, respectively, and whose creation took place in a space of time of less than ten years (Forbes, 2016). In individual transport market passenger, Uber, was founded in 2009 and in 2015 offered its services in 474 cities in the world (UBER, 2016), and has brought real benefits to their business model to compare with other companies operating in same sector.

Laurell and Sandström (2016) exemplify how that disruptive business models in the case brought by them, UBER, emerged in a market of collaborative media platforms to enter into a niche market as the individual passenger transport. According to these authors, the phenomenon of disruptive business and disruptive technology is on the market size and penetration potential in the market. Market factors presented by Laurell and Sandström (2016) are price, response time, service quality and availability. The service makes a comparative cost and time of passenger transport individual call until the arrival of the vehicle at the user port.
In Table 2 shows that the average cost of Uber in both cities surveyed is more than 50% lower than that of traditional service passenger transport individual. Indicative Average Time Waiting and Major Wait Time shows that the Uber service has a shorter waiting time. Thus, with the Individual Transport Passenger market (ITP) as an object of study, it is clear that this has undergone significant changes in the segment called "door to door" (pre-booking, taxi-booking or phone booking, as known in international literature), with the entry of agents that enable the transportation of passengers through paid rides. This market seems is not yet saturated when it is the number of inhabitant’s ratio by taxi fleet, according to Table 2:

Although work only one of the three segments of the ITP, it is likely that the Uber entry as a new player in Brazil also affects street segments (hailing) and taxi ranks (taxi rank), which may cause the decrease in demand for the traditional service ITP. Moreover, as the goal of this new mode focuses on increasing the well-being of society through the top replacement to private cars and taxis, it has also promoted the rivalry with these markets, causing reduction in the price of the races, the lease vehicles and new and used car market (LAURELL, Sandstrom, 2016). also creates some new business possibilities: Taxi drivers do not permit owners can choose to remain in activity or migrate to the paid passenger transport; dealers and rental companies have the chance to create specific lines to meet this market; rental cars have a new niche to provide their products (LAURELL, SANDSTROM, 2016).

However, one must understand that one of the main problems faced by drivers who fall in this market is the lack of regulation of the activity (OLMOS; FAVERA, 2015), an argument used by taxi services providers and some regulatory and legislative authorities to characterize the activity as illegal and unfair, bringing as implying prohibition decisions and banishment of applications and carpooling service itself paid. On the other hand, the carpooling service providers paid and consumer groups have argued that the entry in
the individual transport passenger market has been blocked by lobbying taxi drivers, made possible the capture of regulatory and legislative authorities (ESTEVES, 2015).

In order to solve this impasse, the city of São Paulo took the lead and, after the failed attempt to pass the bill in the City Council, Mayor Haddad issued Resolution No. 01 on 12 May 2016 that, through Decree No. 56,981 / 16 regulates the activities of Accredited Transport Technology Operators for the operation of individual transport activities of public utility and carpooling.

Already in Belo Horizonte, the law 10.900 / 16 sanctioned by the mayor Marcio Lacerda and providing fine of $ 30,000 to passenger transport drivers who are not registered in the municipal office of transit BHTrans, is still suspended by granted injunction the 1st Court of Public Finance. Demonstrations by taxi drivers and attacks on drivers of individual transport passengers paid ride has often been reported in the media. Nevertheless, citizens have used the transport services on a day-to-day, as Estado de Minas newspaper with the headline “Universities and parties are among the most chosen destinations for Uber passengers” (Cruz, 2016).

About the situation in the city of Rio de Janeiro, despite the judge Ana Cecilia Argueso Gomes de Almeida, the 6th Court of Public Finance of Rio, have decided to make permanent the injunction that guarantees accredited Uber application drivers the right to exercise the activity of individual paid passenger transport, as published in valor.com.br site with the headline “Justice Rio releases Uber activity in the State” (SELM, 2016), the Department of transportation of the City Hall confirmed that it does not consider free use applications as St. Paul did. The Secretary Rafael Picciani says the Rio fleet is sufficient to meet the city’s demand and that legalization of application use for the paid ride is not on the horizon “for now” as Estadão newspaper article with the headline “Rio does not consider Uber release, as did St. Paul “(Pennafort, 2016). Faced with this impasse, the taxi drivers still follow manifesting violently against drivers who operate through the paid passenger applications.

Moving on to the international scene, the UBER traced the profile of partners (UBER, 2016) operating in the North American market. According to the company, people seeking this type of activity wish to adapt the work with your lifestyle and commitments, which means more time to take care of minor children and elderly parents, as well as to devote to his passions. On experience with the transport market, 49% had any experience as a driver. According to the survey conducted by the Benenson Strategy Group, and analysis by Alan Krueger, an economist at Princeton University, the use of the platform by the driver-partner goes from primary source of income as complementation. The predominant profile man, 30 to 50 years and uses the income to support their families or as an income supplement for leisure activities. About this research, it concluded that it can divide partners into four groups, as follows:

a) The Pros - representing 18%, are composed of the Uber BLACK partners. It makes up most of those who use the platform for more than 6 months;

b) Crossover - as well as The Pros represent 18%, and is in the group of taxi drivers and luxury drivers who are using UberX less than six months;

c) New Enthusiasts - being the smallest of all, with 12%, is characterized by new users who consistently
took the platform as claim that the activity maintains a stable income;

d) Part-Timers - 52%, this is the most representative group of partners who are in UberX, and have as motivation the opportunity to get a flexible earnings. It is also known that 75% of people in this group have other jobs.

Still about the research, it was found that most respondents prefer to own the business itself and to choose working hours itself, believing that this would allow them to balance time between work and personal life. Another extracted information is that more than half of the partners already working in the transportation sector, and the platform was preferred over the taxi due to the high cost of entry this.

About the gains generated by the platform, the partners say they are financially better. This is confirmed by the more than $ 650 million paid by Uber to drivers in 2014. Under this scenario, most of them, 74% want to keep the activities in the passenger transport market as a way to supplement earnings (UBER, 2016).

As a benefit to the cities, the survey showed that policymakers are recognizing the flexible economy as a significant opportunity. For reference, in 2014 twenty-two jurisdictions (cities and states) adopted modern and smart regulations for hitchhikers sharing industry, ensuring that Uber and other platforms can continue to connect passengers and securely drivers with confidence and trouble-free.

The Legislature in Brazil from the Constitution of the Republic of 1988 establishes globalization trends parallel with the economic assumptions and law. Free competition is a right of freedom, based on Article 5 of the constitution, the business being disruptive a form of free competition (PEREIRA, CORDEIRO, 2015).

Given the amount of information that are necessary for the best decision making becomes necessary to create a tool that allows the future driver envision the possibilities, set clear goals and map the positive and negative risks on the market in which you want inserting. In general, the beginning of the activity has occurred without this analysis, as many Brazilians have seen this business the opportunity to earn income while unable to outplacement. The information contained in the database were taken with the city of Rio de Janeiro-RJ reference.

Then follows a proposal to develop a data compilation and organization of the same through spreadsheet, whose interface is proposed to be intuitive since end users may not be familiar with the technology. The use of this medium is due to the convenience and ease of access to PC's - 78% of Brazilians have computer, according to the 27th Annual Survey of IT Use (Getulio Vargas Foundation, 2016).

3 METHODOLOGY

About logical structure, the flow chart is designed by creating two macros areas which will be composed by data on Costs and Revenues. The costs are composed of two sub-areas, the values for the vehicle and driver. The data for these fields will be obtained through government agencies, in the case of taxes and fees, and specific sites of recognized bodies in the market as the FIPE - Economic Research Institute Foun-
dation. If there is no information, will be three price quotations in the market town of Rio de Janeiro-RJ, always using up the most representative value in order to avoid possible distortions. The goal of treating costs in this way is to allow the user greater flexibility in the handling of information, and enable the creation of different scenarios. Forward, in the case of the revenue area, the future driver can set what will be the duration and period of their working hours, as well as the desired compensation.

With the integration of data obtained through the processes mentioned above, you will realize the power of the spreadsheet to present clearly the business is viable or not, i.e., whether the strategy defined by the user will result in profit. If the answer is negative will then need to make changes to that view the best strategy suits the entrepreneur’s profile. This is because the income generated is presented as a baseline report for you to do the monitoring of project progress. Therefore, the spreadsheet will serve as a means of planning and control of the business. Thus, with the schedule and budget information in hand, the future driver can better manage their periods of work and create in him the motivation to set new goals.

About the method for performing the calculations, the traditional theories investments are employed, which are represented by:

- **Discounted Cash Flow - DCF** is widely used for investment analysis, and aims to determine the value of future estimated cash flows, discounting the appropriate cost of capital (SAITO, JUNIOR and OLIVEIRA, 2008). The main tools that use the concept of DCF are the Net Present Value - NPV and internal rate of return - IRR;

- **Net Present Value - NPV** takes into account the value of money over time. It is obtained by subtracting the initial investment (CF0) the present value of its cash inflows (CFt), discounted at a rate equal to the opportunity cost of the company (k) (GITMAN, 1984).

- **Internal Rate of Return - IRR** is the index indicating the profitability of an investment by a unit of time (MOTTA and CALÔBA, 2002). It is the compound interest rate that will return the NPV of an investment value of 0 (zero). If the IRR is greater than the cost of capital (r), it is accepted the project.

- **Cost Benefit Index - CBI, Payback and Return on Investment Added - ROIA** is the benefit of criteria / cost (Cr / Co) where the relationship between the present value of benefits (CF) and the present value of costs (I) (GITMAN, 1984).

3.1 Structure Tool

For preparation of this tool, the flowchart whose logic is to obtain data on the costs and revenue was created, and at the end, the processing of this information allows decision-making to enter the individual passenger transport business. The general structure thereof is shown below:
The flowchart was then divided into two major areas: Cost and Revenue. The cost area is about the amounts to be invested by the entrepreneur. Strategically, this area is composed of the vehicle costs and driver costs. User tool must enter the data as the fields described. Thus, the values are the actual data to be used for analysis. At this point, it must define its vehicle acquisition strategy is for rental, purchase or adaptation. It is understood that this item is the greatest impact, and therefore share the vehicle with another partner becomes a mitigation measure interesting costs. Another item of impact is the fuel, which must be analyzed for performance. The remaining items relate to the maintenance, cleaning, taxes and insurance. As for the driver costs, deal with the same qualification. Ahead, on the area of Revenue, deals with the strategy and the work load and period in which the partner will act. The first item refers to the amount of hours worked, while the second reflects the quality of those hours. Therefore, it is available on the platform’s website (UBER, 2106) a chart which consists times with higher demand in order
to assist the entrepreneur to optimize your time. This allows it to more flexible working hours with the
demands of daily routine. Finally, this information is compiled and then shows the result on the user-chosen scenario. Given the impracticality of the business, it is suggested that new scenarios are drawn.

As a demonstration of the tool interface, it has the image below:

**Figure 02: Decision toll presentation**

**ECONOMIC FEASIBILITY STUDY - INDIVIDUAL CARRYING PASSENGERS**

<table>
<thead>
<tr>
<th>Entrepreneur:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>City:</td>
<td>App:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) REVENUE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(+) Gross revenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-) Service tax Uber - 25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-) Tribute - Income tax 27,5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(=) Net revenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-) COSTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-) From Conductor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-) From Vehicle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(=) Total Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(=) RESULT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(=) Total</td>
<td>R$</td>
<td>R$</td>
</tr>
</tbody>
</table>

Average Monthly Income
R$  | R$  | R$  |

It's viable?

**4 BUSINESS CASE**

As a case study, the analysis was performed for an entrepreneur who want to act in the city of Rio de Janeiro-RJ. The assumptions used to delimit the study were:

a) Revenue Generation
- Hours of work: 09 hours / day
- Days worked per week: 06 days
- Analysis period: monthly
- Estimated non-productivity: 30%
- Average speed of travel: 50 km /h
b) Costs Generation
- Vehicle Acquisition: Semi-new installment in 36 months (Table Price)
- Fuel: NGV kit installation
- Fuel Yield: 14 m³ / km
- Garage: own
- Passenger insurance: required by the platform
- Maintenance and cleaning of the vehicle: Monthly
- Fees and taxes: property taxes, CRLV, Insurance and Licensing
- Vehicle Depreciation: Annual 10%
- Driver Enable: portfolio renewal with inclusion of gainful employment Annotation
- Income Tax: as table IRS
- Security: carnet MEI
- Communication: Internet 4G - 4GB (as UBER orientation)
- Application usage rate: as each platform policy

On the variables mentioned above, it is expected that there is a monthly fee of at least 4 times the minimum wage, ie, R$ 3,500.00, so that the business becomes viable. It must be stressed that as a source of revenue generation were considered the same values for the entire period, since the price of pay is defined by the platform of the company and due to business strategy, this information is not disclosed. However, it is known that Uber has the tendency to reduce the amount of compensation (Pfaffenbach, 2015) in order to minimize the non-productivity of partners increasing demand. Therefore, it is understood that the amount of revenue will suffer great impact, according to the study presented by the Uber in the matter posted on its website under the title “4 Setembers of UberX in NYC.” In addition, the study was not considered the Rate Multiplier Factor, which is a dynamic revenue increase based on passenger demand and partner availability. Therefore, it is possible to obtain greater profits than the one presented by the tool in the study.

Enter information in the spreadsheet, it was possible to realize that it is really feasible to use it as a tool for decision making in individual transport passenger market. However, it must be stressed that the figures used for the preparation of the file were based in the city of Rio de Janeiro-RJ. However, the fields are enabled to be updated with the user’s local information, bypassing thus possible distortions. Then it will be up to the future entrepreneur to get the data to fine-tuning.
Once the information is grouped in this tool is intended to provide a future addendum that allows the monitoring of the business, i.e., enables the control thus showing both the current result as the monthly trend and annual.

5 CONSIDERATIONS

Finally, the individual transport passenger market, as well as several areas of the market, has undergone profound changes as seen during the preparation of this work. Therefore, responses to business viability in the city (ESTEVES, 2015) and regulation mode (FAVERA, 2016) make it necessary for the market to continue to operate in order to promote economic and social development. In addition, other problems such as providing data for academic studies also need to be remedied. This is because once such information was provided by public bodies, now they make up the strategic basis of the companies operating the market.

Resuming the 27th Annual Survey of IT Use conducted by FGV / 2016 where it is shown that there are 1.2 mobile wireless devices connectable to the Internet per capita in Brazil, it is expected to further the tool proposed in this paper is made possible in the form of application since smartphones are now part of Brazilian life. This will enable a more agile management, and enable data collection for studies of this market.

Barbaschow, A.


Meirelles, Fernando de Souza. 27ª Pesquisa Anual do Uso de TI. Centro de Tecnologia de Informação Aplicada da EAESP. Fundação Getúlio Vargas. 2016


Souza, Felipe. Viagem barata: Por que motoristas do Uber estão protestando contra a empresa no Brasil.
Estimation of Concrete Volume of Vertical Buildings by Means of Multiple Linear Regression
Marcio Soares da Rocha

ABSTRACT

Many real estate projects are launched based on feasibility studies, which in turn are based on cost estimations prepared from architectural blueprints. Although in Brazil the previous estimated cost of a vertical construction is most practiced on the basis of the constructed area using the CUB (Basic Unit Cost), recently many engineers have preferred to draw up more detailed and more accurate estimation budgets, called parametric budgets. In these parametric budgets, the quantitative budget items of the construction that can be obtained directly from the draft are raised and the quantity of the items not yet designed or detailed in the draft (such as the volume of concrete, the amount of hydraulic pipes and fittings, electricity pipes and others) are estimated. The methods adopted until now for the estimation of the volume of concrete of buildings in Brazil are empirical and based in the constructed area and in the index named Espessura Média do Concreto (Average Thickness of Concrete). This author has noted that the actual estimating parameters permit not the assessment of their accuracy and may lead to considerable and undesirable mistakes. Thus, a linear regression model was developed using data of some detailed budgets of buildings designed in Brazil in the last four years and was obtained a more precise parameter for estimating the volume of concrete of a building, by which one needs only the number of floors of the tower and its paved floor area. The equation obtained allows that the estimation of the building's volume of concrete is made quickly and with good precision, being a very useful tool for cost estimators. In addition, the adopted method can be used to obtain mathematical models based on previous detailed budgets prepared by the construction company itself, providing even greater precision to the estimation and it can be used as a model to deduct other parameters for estimation of other items of preliminary budgets.

Keywords: cost estimation, quantitative estimation, vertical building.

1 INTRODUCTION

The real estate enterprises must have their costs estimated before they are launched to the market and many investors and entrepreneurs need to estimate the costs of the intended buildings even before their projects are completely detailed. Most of the cost estimations of new real estate enterprises are made based on the architectural blueprints/drafts and, in Brazil, is commonly used the method of expeditious
budgeting, which basically consists in multiplying the constructed area by the basic unit cost (CUB), incrementing some additional costs (direct and indirect) not included on the value of the CUB.

An expeditious budget, according to studies published by the Brazilian Institute of Cost Engineering (IBEC) and the Brazilian Institute of Public Works Audit (IBRAOP), has a precision of up to 70% with respect to the actual price. To improve the accuracy of the preliminary estimations, some professionals have prepared parametric budgets, which consist of detailed budget sheets, in which most of the services quantities are calculated from the architectural draft and the rest are estimated based on parameters inferred from data of other similar works or parameters published in studies done by some authors. In the parametric budgets, often the costs of the services are obtained in similar works already executed. This type of budget has, according to the cited institutes, accuracies of approximately 80%, and therefore is more accurate than expeditious budgets.

One of the quantities that needs to be estimated in preliminaries budgets is the volume of concrete, once, only with the drafts, the structural design is not yet done. There are some parameters for concrete volume estimation published in Brazil (Solano, 2003; Mattos, 2006; Mendes, 2013; Gonçalves and Ceotto, 2014) and they are based only on the built up area and on an index named Espessura Média do Concreto (Average Thickness of Concrete). These estimation parameters were established empirically by their authors, based mainly on their professional experiences, and they allow not an evaluation of their precision. It is noted by this author that there is need for estimation parameters that are drawn up on the basis of scientific methods and that allow the assessment of the precision of the estimation.

This work establishes an equation for estimating the volume of concrete in vertical buildings, which was deduced by means of multiple linear regression. For the deduction of the equation presented here, were researched initially 23 (twenty-three) budgets of vertical constructions performed in several cities in Brazil, published by Editora PINI (PINI editor) in its magazine named Construção Mercado (Construction Market) in the last four years. After the deletion of the data considered eccentric (outliers), the model featured a sample of 18 budgets. The statistics of the model indicate that the equation here inferred has a good degree of accuracy and, therefore, constitutes a more appropriate parameter for the estimation of the volume of concrete of vertical buildings with physical characteristics similar to those included in the sample.

The estimated parameter deducted in this work is useful for the elaboration of parametric budgets in Brazil, due to the speed and facility with which it allows the estimation of the volume of concrete of the building being quoted, and because it has the appropriate precision of this kind of budget. Once estimated the volume of concrete, this data can be used for the estimation of other budget quantities relating to concrete, i.e. steel consumption (by weight) and the area of wood shape boards. The estimation equation here inferred also serves as reference to audit the concrete quantitative constants in detailed budgets. More broadly, the method can be applied to deduce some quantitative estimation parameters of engineering works in other countries or in certain regional markets.

It is hoped that this paper be consulted by cost estimators in Brazil and that the parameter here inferred is used to estimate the volume of concrete of vertical buildings, in economic feasibility studies of real estate enterprises.
2 LITERATURE REVIEW – ESTIMATION PARAMETERS OF CONCRETE VOLUME PUBLISHED IN BRAZIL


\[ V_{conc} = Ac \times 0.172 \]  \hspace{1cm} (1)

Where:

- \( V_{conc} \) = concrete volume of the tower
- \( Ac \) = constructed area of the tower

Mattos (2006) published a table that contains a parameter for concrete volume estimation based on the built-up area of the building and on an index named Espessura Média do Concreto (Average Thickness of Concrete). His equation is listed in Table 1.

<table>
<thead>
<tr>
<th>Superior structure</th>
<th>Espessura Média do Concreto (EMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 10 floors</td>
<td>Between 12 and 16 cm</td>
</tr>
<tr>
<td>Above 10 floors</td>
<td>Between 16 and 20 cm</td>
</tr>
<tr>
<td>Concrete Volume</td>
<td>Constructed Area of the tower x EMC</td>
</tr>
</tbody>
</table>

Mendes (2013) published his estimation parameter of the concrete volume of engineering works, which is based on the built up area and on an empirical coefficient. His estimation equation is the Equation 2.

\[ V_{conc} = Ac \times 0.23 \]  \hspace{1cm} (2)

Where:

- \( V_{conc} \) = concrete volume of the tower
- \( Ac \) = constructed area of the tower

Gonçalves and Ceotto (2014) published their concrete volume estimating equations based on the constructed area and in Espessura Média do Concreto (average thickness of concrete), by type of building (residential or commercial). Its parameters have been deducted from their professional experiences as cost estimators of vertical buildings 16 up to 27 floors. The Gonçalves and Ceotto (2014) parameters are the Equations 3 and 4.

For residential buildings:

\[ V_{conc} = At \times (0.23 \text{ a } 0.27) \]  \hspace{1cm} (3)
For commercial buildings:

\[ V_{\text{conc}} = At \times (0.28 \text{ a } 0.30) \]  

(4)

Where:

\( V_{\text{conc}} \) = concrete volume of the tower  
\( At \) = constructed area of the tower

None of the cited authors, with the exception of Parissoto (2003), published the methodology by which they deduced their respective estimation parameters. The parameter by Solano (2003), according to Parissoto (2003), was obtained from the division between the volume of concrete and the built area of the given standard project adopted by Solano (2003). Therefore, it is observed that the estimation parameters of concrete volume published so far in Brazil were empirical, based on the professional experiences of their authors or of others to whom those consulted.

3 METHOD, DATA AND PREVIOUS ESTABLISHED APPROVAL CONDITION OF THE MODEL

3.1 Method

The method adopted in this work was the multiple linear regression, which consists in modelling for the analysis of the relationship between a dependent variable \( (Y) \) and other independent variables \( (X_1, X_2, ..., X_n) \). The goal of regression analysis is to identify the function which best describes the relationship between these variables, so that it is possible to predict which is the value that the dependent variable \( (Y) \) assumes, given the specific values to independent variables \( (X_1, X_2, ..., X_n) \). The result of this analysis is an estimation equation of the value of the dependent variable, according to the model of Equation 5, which is deduced from the independent variables in the adopted model, so that they are meaningful to the explanation of the value of the dependent variable.

\[ Y = AX_1 + BX_2 + CX_3 + ... ZX_n \]  

(5)

In the present study, the explained variable (dependent) is the concrete volume of the tower including the ground floor \( (V_{\text{conct}}) \) and the explanatory variables (independent) adopted are the number of floors of the Tower \( (N_{\text{pvt}}) \) and the paved floors area of the tower \( (A_{\text{pist}}) \). The number of floors and the paved floors area of the tower are data obtained with relative facility in withdrawals from the blueprints. The volume of concrete of the foundations is not analysed in this paper research, because it is a function of more variables, which in turn are related not only to the physical characteristics of the building, but also to the physical characteristics of the soil and subsoil where the building will be built.

3.2. Data

In the present work the multiple linear regression was applied to a sample composed by 23 (twenty-three) detailed budgets of vertical buildings. 22 (twenty-two) budgets have been published in the magazine
Construção Mercado (Market Construction) of PINI editor and a by a budget that was elaborated by this author. Of the twenty-three initial sample data, five data were disregarded by having different physical characteristics when compared to the majority of the other data, constituting, then, outliers that undermined the model. The 18 (eighteen) data that generated the model are described in Table 2.

Table 2 – Data of the present work

<table>
<thead>
<tr>
<th>#</th>
<th>Building</th>
<th>Information Font of The Budget</th>
<th>Number of Floors, including the ground floor (Npvt)</th>
<th>Paved Floors Area of the Tower (Apist)</th>
<th>Concrete Volume of the Tower (Vconct)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Residencial Popular em Curitiba</td>
<td>CM Magazine¹, number 168 (2015, July)</td>
<td>16,00</td>
<td>6.148,46</td>
<td>1.480,00</td>
</tr>
<tr>
<td>2</td>
<td>Residencial em Goiânia</td>
<td>CM Magazine, number 153 (2014, March)</td>
<td>16,00</td>
<td>9.360,63</td>
<td>2.023,00</td>
</tr>
<tr>
<td>3</td>
<td>Residencial de Alto Padrão</td>
<td>CM Magazine, number 160 (2014, November)</td>
<td>16,00</td>
<td>4.607,64</td>
<td>1.128,00</td>
</tr>
<tr>
<td>4</td>
<td>Residencial em Vitória Padrão Normal</td>
<td>CM Magazine, number 158 (2014, September)</td>
<td>13,00</td>
<td>5.811,30</td>
<td>1.100,00</td>
</tr>
<tr>
<td>5</td>
<td>Edifício em Fortaleza</td>
<td>CM Magazine, number 161 (2014, December)</td>
<td>11,00</td>
<td>1.975,17</td>
<td>474,00</td>
</tr>
<tr>
<td>6</td>
<td>Not informed</td>
<td>CM Magazine, number 166 (2015, April)</td>
<td>10,00</td>
<td>2.969,82</td>
<td>595,68</td>
</tr>
<tr>
<td>7</td>
<td>Residencial em João Pessoa</td>
<td>CM Magazine, number 151 (2014, February)</td>
<td>6,00</td>
<td>2.825,78</td>
<td>448,00</td>
</tr>
<tr>
<td>8</td>
<td>Residencial Popular em Fortaleza</td>
<td>CM Magazine, number 157 (2014, August)</td>
<td>15,00</td>
<td>4.479,22</td>
<td>1.016,00</td>
</tr>
<tr>
<td>9</td>
<td>Hotel Padrão Médio em Brasília</td>
<td>CM Magazine, number 171 (2015, October)</td>
<td>6,00</td>
<td>2.528,29</td>
<td>450,00</td>
</tr>
<tr>
<td>10</td>
<td>Residencial em Porto Alegre</td>
<td>CM Magazine, number 170 (2015, September)</td>
<td>11,00</td>
<td>2.810,21</td>
<td>604,00</td>
</tr>
<tr>
<td>11</td>
<td>Residencial em Salvador-BA</td>
<td>CM Magazine, number 149 (2013, December)</td>
<td>11,00</td>
<td>2.766,63</td>
<td>754,66</td>
</tr>
<tr>
<td>12</td>
<td>Residencial em Recife</td>
<td>CM Magazine, number 148 (2013, November)</td>
<td>11,00</td>
<td>5.789,57</td>
<td>1.166,00</td>
</tr>
<tr>
<td>13</td>
<td>Residencial Padrão Médio-Alto em Brasilia</td>
<td>CM Magazine, number 146 (2-13, September)</td>
<td>7,00</td>
<td>2.205,05</td>
<td>493,45</td>
</tr>
<tr>
<td>14</td>
<td>Residencial em Florianópolis</td>
<td>CM Magazine, number 174 (2016, January)</td>
<td>13,00</td>
<td>4.202,00</td>
<td>921,00</td>
</tr>
<tr>
<td>15</td>
<td>Residencial em Salvador Comercial em Pernambuco</td>
<td>CM Magazine, number 172 (2015, November)</td>
<td>13,00</td>
<td>3.501,86</td>
<td>695,00</td>
</tr>
<tr>
<td>16</td>
<td>Residencial em Belo Horizonte</td>
<td>CM Magazine, number 164 (2015, March)</td>
<td>6,00</td>
<td>6.449,73</td>
<td>1.136,96</td>
</tr>
<tr>
<td>17</td>
<td>Residencial Kyrios em Fortaleza</td>
<td>CM Magazine, number 153 (2014, March)</td>
<td>16,00</td>
<td>4.607,64</td>
<td>1.128,00</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>Budget elaborated by this author (2012)</td>
<td>17,00</td>
<td>5.426,00</td>
<td>1.176,04</td>
</tr>
</tbody>
</table>
The sampling variance of the independent variables of the model is described as follows.

- Number of floors = from 6 to 17.
- Paved floor area = from 2.205 m$^2$ to 9.360,63 m$^2$.

### 3.3 Software for modelling

In order to develop the multiple linear regression model, was used the software Action 2.8.

### 3.4 Previous established approval condition of the model

It was established by this author as a condition of approval of the model that the estimated values could not introduce variation (residue) greater than 20% in relation to the volume of concrete of any sample data, so that the condition of 20% precision of estimates made by means of parametric budgets could be met.

### 4 RESULTS

#### 4.1 Estimate equation and statistics of the model

The estimate equation generated by multiple regression analysis, based on data from the Table 3.1 and elaborated with the confidence grade of 90% is the equation 5.

$$V_{\text{cont}} = -189.1828879 + 27.28395776 \times N_{\text{pvt}} + 0.18296457 \times A_{\text{pist}} \quad (5)$$

Where:

- $V_{\text{cont}}$ = concrete volume of the tower
- $N_{\text{pvt}}$ = number of floors of the tower
- $A_{\text{pist}}$ = paved floors area of the tower

Statistics of the regression model:

- Correlation Coefficient (R) = 0.9851
- Determination Coefficient (R$^2$) = 0.9704
- Adjusted Determination Coefficient (R$^2_a$) = 0.9664
- Standard deviation (e) = 76.1321 m$^3$

The present model was approved in the tests defined by the Brazilian technical standard NBR 14653-2/2011, regarding the maximum significance of the independent variables (t test), the maximum model’s significance (F test), the test of linearity, of normality, of collinearity, and of outlier and influencer points.

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$^1$Revista CM PINI = Revista Construção Mercado.
- Significance of the variable Npvt = 2.1685%
- Significance of the variable Apist = 0.0000006%
- Significance of the model: 3.4348434735789E-11
- Correlation between the variables Npvt and Apist: 0.49%
- The graphic Resíduos padronizados x Valores ajustados (Standard Residues x Adjusted Values) indicate linearity and normality of the data.
- No residue is out of the interval [-2 +2], indicating absence of outliers or influencer points.

The biggest residue was obtained from the sample data number 11, which showed the residual value of 18.22%. No data presented a variation greater than 20% in relation to the concrete volume; therefore, the condition of 20% of precision in estimations made by means of parametric budgets has been met.

Figure 1 – Reports generated by the software Action 2.8 – ANOVA Table, variable coefficients and t statistics

Figure 2 – Reports generated by the software Action 2.8 – Standard Deviation, R2 and Adjusted R2
Figure 3 – Reports generated by the software Action 2.8 – Table of Correlations

<table>
<thead>
<tr>
<th></th>
<th>N Pvt</th>
<th>AπisoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Pvt</td>
<td>1</td>
<td>0.496030397</td>
</tr>
<tr>
<td>AπisoT</td>
<td>0.496030397</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4 – Reports generated by the software Action 2.8 – Graphic Resíduos Padronizados x Valores Ajustados
4.2 Limits for application of this estimating parameter

It is recommended that the estimating parameter of the present work is not applied to buildings with number of floors greater than 25 and less than 04, and that is not applied to buildings with floor areas exceeding 13,300.00 m² or less than 1,000.00 m².

The model developed in this work shall not be applied to buildings that have the Índice de Massa Predial (building mass index) greater than 1,075.00. The Índice de Massa Predial index is calculated by dividing the floor area of the building by its number of floors (including ground floor), as in Equation 6.

\[
Imp = \frac{Apist}{Npvt}
\]  

(6)

Where:

- \(Imp\) = Índice de Massa Predial (building mass index)
- \(Apist\) = paved floors area of the tower
- \(Npvt\) = number of floors of the tower
5 CONCLUSIONS AND SUGGESTIONS

5.1 General paper conclusion

The statistics and the results of the tests demonstrate the accuracy of the estimating equation deduced in the present study and its suitability as a preliminary estimator parameter of concrete volumes of the towers of vertical buildings whose physical characteristics are within the limits set out in 4.2.

5.2. Application example of the estimator parameter developed in this study

The model here developed (Equation 5) can be applied to estimate, for example, the concrete volume of a vertical building tower with 15 floors and paved floors area of 5,000 m². The volume of the concrete tower of this building is estimated at 1,134.90 m³, as demonstrated below.

\[ V_{conct} = -189.1828879 + 27.28395776 \times N_{pvt} + 0.18296457 \times A_{pist} \quad (5) \]

\[ V_{conct} = -189.1828879 + 27.28395776 \times 15 + 0.18296457 \times 5,000 \]

\[ V_{conct} = 1,134.90 \text{ m}^2 \]

5.2 Suggestions for future studies

The present study can be extended and performed with greater number of sample data and greater number of independent variables, for greater precision. It can also be performed with regionalised samples, resulting in regional estimators parameters or based on previous budgets of a certain construction company, which may also result in greater precision of estimation.

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An Analysis of Liquidators’ Reports for Construction Companies in New Zealand

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²University of Moratuwa, Sri Lanka;
³University of Cape Town, South Africa;

ABSTRACT

Purpose of this paper

Project owners payment obligations need to be met timely on construction projects otherwise construction parties could become adversely affected. In worst situations, constructors’ businesses become insolvent and liquidators are brought in to oversee the management of their assets and liabilities. This study analyses liquidators’ reports for information on the nature of liquidation proceedings, and their effects on unsecured creditors of affected companies.

Design/Methodology/Approach

The study adopts a content analyses approach to data analysis, and the results presented descriptively for ease of understanding.

Findings and Value

The results obtained show that a general economic downturn meant cash flow irregularities and bad debts in the New Zealand construction industry. Worst hit were trade creditors of affected companies who were largely unsecured, and with a significant proportion unable to receive full settlement of their claims.

Originality/Value of the paper

The study findings are useful for re-establishing contractual and regulatory provisions for prompt settlement of payment claims on construction projects in New Zealand.

Keywords: Liquidation, Payment Losses, Construction Industry, New Zealand
INTRODUCTION

Project owners payment obligations need to be met timely on construction projects otherwise construction parties could become adversely affected. In worst situations, constructors’ businesses become insolvent and liquidators are brought in to oversee the management of their assets and liabilities. It is suggested that the industry operates under a cascade system of payments which causes a ‘domino effect’ on lower tier parties, consequently the crippling consequence of insolvency (Latham, 1994; Eugenie, 2006). Payment problems become severe when participants higher in the contractual chain become insolvent, as the obligations down the chain increases.

Insolvencies are a common occurrence in the construction industry and are correspondingly higher than other industries (Ashworth & Hogg, 2007; Davis, 1991; Langford, Iyagba, & Komba, 1993). The construction industry accounts for 12% of all business failures in the United States (US) (Touran et al., 2004). In New Zealand, insolvencies in the construction industry have been between 10-12% of all industries (Statistics New Zealand, 2011). Figure 1 shows that construction firms ranked third on the list of business failures in New Zealand. The figure shows an increase from nearly 5600 liquidation in 2001 to around 6,300 in 2011. For the period 2001 to 2011, the average company incorporation rate was 11.4% while liquidation rate was 12.4%. This reveals that on the average construction experienced a net loss of 1.0% of businesses on an annual basis, corresponding to about 1150 job losses and $300 million lost in national revenue. The construction industry comprises nearly 50,000 enterprises, providing employment to over 114,000 (Statistics New Zealand, 2011). Comparative data on insolvencies in Australia, show that construction industry is ranked highest at 24%, followed by 22% and 10% in personal and business services and the retail industry respectively (Hammond, 2010). Hammond (2010) shows further that insolvency is more prevalent amongst small businesses (about 77% of overall total) employing less than 20 employees. These construction insolvency trends demonstrate the prevalence of the problem and its significance, not only to the construction industry but to national economies.

![Figure 1 Business deaths by industry (Statistics New Zealand, 2011)](image-url)
The construction industry's contribution to insolvency statistics is not proportional to its positive contribution to gross domestic product (Davis, 1991). Its volatility and vulnerability to general economic conditions stem from the direct relationship between the industry and the national economy. Furthermore, the fragmented nature (large number of small firms) of the construction industry exposes its small firms to higher than normal levels of competition. The operational activities of these smaller firms are dependent on overdraft facilities and trade credits which require a steady flow of income to be able to manage their activities effectively. These inherent characteristics coupled with poor payment cultures place the industry at financial high risks and general business failures. Latham (1994) had identified poor payment culture, especially non-payment of invoices as a bane of the industry. Ultimately parties in the supply chain incur financial losses. Davies (2009) study also shows that construction parties experience financial difficulties and often resort to requests for advance or early payments from their principal, or deliberately withhold payments from their lower tier parties.

Childs (2009) suggests that liquidation is distracting and can lead to major disputes between parties to a contract. Liquidation proceedings are very often protracted and an ill wind that blows none of the parties any good. Very rarely do affected parties in liquidation proceedings, secure proper compensation for their losses. Donnelly (2009) and Marlborough Express (2008) provide examples of trade creditors that were paid on a pro rata basis for losses incurred when project owners’ went into liquidation. Unsecured creditors are usually the worst hit (Barry, 2010).

Several preventive and protective mechanisms have been developed to curb the impact of insolvencies on affected parties. For example, ascertaining, the financial ability of a principal prior to commencement of projects is suggested by Davies (2009). If the financial strength is unsatisfactory, a contractor could request its client to provide some sort of security in the form of bonds and guarantees or advance payment into an escrow account (Davies, 2009). The magnitude of the security procured is dependent on a good evaluation of the potential for business failure risk, by the contractor. Dikmen, Birgonul, Ozorhon and Sapci (2010) suggest that information specific and external variables along with the knowledge and experience of experts provide the best model to diagnose business failure risks of client organisations.

Furthermore, Security of Payment legislation are now operational in most countries, to serve as financial protection mechanisms for their whole-of-industry. These abolish traditional pay-when-paid clauses, which principals have used to justify their payment defaults to lower tier parties. Although Ramachandra and Rotimi (2016) suggest that these legislation do not altogether offer protection from deliberate attitudinal defaults.

Conclusively payment problems persist in the construction industry and liquidation of construction companies remain significant. The study proposes that reports on liquidation proceedings could yield information on the magnitude of the problem, the nature of the problem and their effects on unsecured creditors of affected companies. The study therefore has as its aim, the analyses of the content of liquidators’ reports for construction companies in New Zealand with the intention of establishing the effects of liquidation on contractual parties.
2 STUDY APPROACH

This paper is primarily based on information sourced from the website of one of the insolvency and business recovery specialists (http://www.mvp.co.nz/) in New Zealand. The Liquidators’ reports covered construction companies in three main subsectors: property development, general construction and trade services. Information obtained from the Liquidators reports include: date of incorporation of companies, nature of the business, types of liquidation, duration of liquidation proceedings, value of debt and the reasons for liquidation. A total of 81 companies were liquidated within the period of analysis (2005-2010), however only 65 companies are analysed in this study. The companies comprise: 22 in property development (PD), 27 in general construction (GC), and 16 in construction trade services (CTS). A fuller breakdown of the companies analysed is provided in Table 1.

Table 1 Breakdown of Companies in Liquidation

<table>
<thead>
<tr>
<th></th>
<th>Property Development (PD)</th>
<th>General Construction (GC)</th>
<th>Construction Trade Services (CTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage (%)</td>
<td>Frequency</td>
</tr>
<tr>
<td><strong>Company incorporation (Year)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before 2000</td>
<td>3</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>2000 - 2005</td>
<td>14</td>
<td>52</td>
<td>15</td>
</tr>
<tr>
<td>2005 - 2008</td>
<td>9</td>
<td>33</td>
<td>4</td>
</tr>
<tr>
<td>N/A</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>100</td>
<td>34</td>
</tr>
<tr>
<td><strong>Liquidation commencement (Year)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before 2008</td>
<td>-</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>2008</td>
<td>11</td>
<td>41</td>
<td>9</td>
</tr>
<tr>
<td>2009</td>
<td>15</td>
<td>56</td>
<td>9</td>
</tr>
<tr>
<td>2010</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>100</td>
<td>34</td>
</tr>
<tr>
<td><strong>Liquidation completion (Year)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>-</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>2009</td>
<td>10</td>
<td>37</td>
<td>11</td>
</tr>
<tr>
<td>2010</td>
<td>12</td>
<td>44</td>
<td>10</td>
</tr>
<tr>
<td>N/A</td>
<td>5</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>100</td>
<td>31</td>
</tr>
<tr>
<td><strong>Types of Liquidation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voluntary</td>
<td>19</td>
<td>70</td>
<td>25</td>
</tr>
<tr>
<td>Involuntary</td>
<td>7</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>N/A</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>100</td>
<td>34</td>
</tr>
</tbody>
</table>

3 DATA PRESENTATION, ANALYSIS AND DISCUSSION

The historical information sieved out from the Liquidators’ reports are analysed, presented and discussed in the following sub-sections.
3.1 Analyses of Demographic Information

The information presented in Table 1 yields some interesting findings. Majority of the companies were incorporated between 2000 and 2005, about 30% were established closer to 2010 and another 30% were established before 2000. Overall about 70% of companies from all three categories went into liquidation within 9 years from 2000 – 2008 of their establishment. It therefore implies that the age of the companies did not significantly influence their liquidation.

Further, 50% of the companies in all three categories were liquidated during 2008 - 2009. All the property development sector companies were liquidated after the year 2008, while about 60% of both general construction and construction trade service companies were liquidated after 2008.

An analysis of liquidation completion times shows that about 70% of the liquidation proceedings were completed between 2009 and 2010. Liquidation completion times help to determine the status of payments to creditors. Generally payment to creditors are realised only upon the completion of liquidation proceedings.

Another important feature captured on Table 1 is the type of liquidation. The data shows that most of the liquidated companies (about 70%) across all three categories went into voluntary liquidation. Which means the companies had elected to go into liquidation rather than by a court action following an application to the Court by a creditor of the company (involuntary liquidation).

3.2 Financial Effects of Liquidation

This section analyses the effects of liquidation on unsecured creditors of the companies that went into liquidation. Determining the amount owed to creditors allows the study to establish the effects that liquidation of construction companies have on creditors. The analysis of the Liquidators' reports show that liquidation affects three categories of creditors: secured, preferential and unsecured. According to the Companies Act 1993 in New Zealand, secured creditors are paid out of the proceeds realised because they generally retain title claims or secured interest over goods or equipment supplied to principals. Thus in liquidation, unsecured creditors are more adversely affected than secured creditors.

As was indicated previously, the amount owed to trade creditors is a proxy and represents payment delays and losses to construction parties. An analysis of the amounts owed to trade creditors in the liquidation of the three major categories (property development, general construction, and construction trade services) of companies are presented under the following paragraphs.

Figure 2 presents information culled from Liquidators reports on the amount owed to trade creditors by the companies in the three subsectors. Over 50% of the companies owed less than NZ$10k to their trade creditors. 18% owed between NZ$100k and NZ$200k; 14% owed NZ$10k-50k; 9% owed above NZ$200k, while a small percentage (4%) owed between NZ$50k and NZ$100k. Detailed analysis of the amount owed by companies below the NZ$10k range shows that nearly 60% of the companies owed between NZ$1k and NZ$5k. This is insignificant when compared to the percentage recorded on higher values. Another 25%
owed from NZ$5k to NZ$10k. From the information obtained, the amount owed to trade creditors is on average about 15% of the amount owed to all unsecured creditors.

Figure 2 Debt owed to trade creditors by companies

Also from information presented in Figure 2, the amount owed to trade creditors by general construction companies varies from below NZ$100k to above NZ$1000k. About 37% owe between NZ$100k and NZ$500k; while 30% owed less than NZ$100k. Nearly half of the companies in the latter two owed between NZ$500k and NZ$1,000k and above NZ$1,000 respectively. The analysis shows that on average the amount owed to trade creditors were 78% of the total amount owed to unsecured creditors. This demonstrates the significance of the effect that the liquidation of companies in general construction could have on contractual parties down the supply chain.

Analysis of Liquidators reports and information provided in Figure 1 helps to determine the effects of amounts owed to trade creditors by companies in construction trade services. In this case the largest percentage, 56%, owed less than NZ$100, while 25% of companies owed between NZ$100k to NZ$200k, and the remaining 19% owed above NZ$200k. A further analysis of the 56% that owed below NZ$100k shows that 67% of them owed between $50k and NZ$100k. It is noted that on average, the amount owed to trade creditors was 66% of the amount owed to total unsecured creditors. This is significant but lower to values obtained on companies in general construction above.

On the whole, Figure 2 helps to summarise the losses experienced by trade creditors during liquidation of the three sub category of construction principals. Amount owed to creditors vary from below NZ$50k to above NZ$200k. A significant percentage (nearly 70%) of property developers owed below NZ$50k while above 50% of general construction companies owed above $200k. Creditors to construction trade services companies were mostly owed between NZ$50k and NZ$100k. The figure shows that financial
losses to creditors of liquidated general construction companies were more significant than those of construction trade services and property developers.

3.3 Status of Payment to Creditors

In a further effort to determine the actual effects of liquidation the study looks at the status of payment to unsecured creditor at the completion of liquidation proceedings. When liquidation proceedings are completed the amounts to be distributed across creditors are established. The Liquidators’ final reports indicate the status of payment to unsecured creditors as either no funds or pro-rated amount. Table 2 provides a summary of payments made to trade creditors obtained from the final reports of Liquidators for companies under the main three categories considered in this study. The result show that among the liquidated property development companies, only one company (5%) partially paid (11.89 cents per dollar) to its creditors. Further, 77% had no funds available to pay their creditors, while the remaining 18% had either no trade creditors or did not disclose the amount owed their trade creditors. There is information on only company that was able to pay its creditors 6 months after the liquidation process was completed. Evidently the time lag between the liquidation proceedings and final settlement would have caused financial distress on creditors.

Companies in the general construction category displayed similar traits at honouring trade creditors after liquidation proceedings. 27 companies in this category that entered liquidation were unable to pay their trade creditors, even partially. One company in the construction trade services category paid its trade creditors fully; about 20% managed to pay a pro rata amount (20 cents per dollar). The majority 75% (12 out of 16) were unable to pay their creditors at all.

**Table 2 Payment Status after Liquidation Proceedings**

<table>
<thead>
<tr>
<th>Nature of business</th>
<th>Number of companies liquidated</th>
<th>Percentage that paid unsecured creditors</th>
<th>Status of payment to unsecured creditors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property developers</strong></td>
<td>22</td>
<td>5%</td>
<td>Partially paid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>77%</td>
<td>No payment at all</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18%</td>
<td>Failed to disclose the amount owed to trade creditors</td>
</tr>
<tr>
<td><strong>General construction</strong></td>
<td>27</td>
<td>100%</td>
<td>No payment at all</td>
</tr>
<tr>
<td><strong>Construction trade services</strong></td>
<td>16</td>
<td>6%</td>
<td>Fully paid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19%</td>
<td>Partially paid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75%</td>
<td>No payment at all</td>
</tr>
</tbody>
</table>

From Table 2, it can be observed that 5% of property developers and about 25% of construction trade service companies partly or fully paid their creditors, the creditors had to wait until the liquidation proceedings were completed to receive their claims. Thus there was a delay in payment to creditors. To determine the duration of the delay, the time taken to complete liquation proceedings was analysed.
The time taken to complete liquidation proceedings was determined as the time difference between the commencement and completion of those proceedings. Figure 3 shows the distribution of time taken for these voluntary and involuntary liquidations.

In the majority of cases, liquidations both voluntary (53%), and involuntary (32%), took 12-24 months to complete. Twelve percent of voluntary and 27% of involuntary liquidations took longer than 24 months however. Thus most liquidations took over a year to complete. Voluntary and involuntary liquidations that took 6-12 months to complete were 24% and 27% respectively, while those that were completed is less than 6 months were 12% of the total of voluntary, and 14% of involuntary liquidations. However, detailed examination of information extracted from the Liquidators’ reports show that on average liquidation proceedings took 18 months to be completed. The time period for complete proceedings varied from a minimum 2 months to a maximum of 72 months over the 4-year period (before 2008 - 2010) investigated. Further examination of the reports shows that the time taken seemed to be shorter for property developers, perhaps because these were usually smaller companies, and the amounts in contention were comparatively lower. Liquidation proceedings took an average 11 months to be completed for property developers. The time taken for liquidation proceedings for construction trade services and general construction companies were longer, with an average of 19 and 25 months respectively.

The analysis of the reports indicate that voluntary liquidation proceedings took longer because of the investigations required into the company’s accounts and reports, the realisation of all assets owned by the liquidated company, and collection of monies from trade debtors and others. Out of 65 companies analysed, only a single company paid its creditors fully, while another 4 paid on a pro-rata basis. The creditors of the remaining companies received no payments at all from liquidation proceedings. The five companies which paid their creditors partly or fully took an average of 18 months after the commencement.
of the liquidation process do so. Thus there is evidence of payment losses and delays experienced by construction parties down the contractual chain due to insolvency of the upper tier parties in construction.

4 CONCLUSION

This study analyses the content of liquidators’ reports for construction companies in New Zealand with the intention of establishing the effects of liquidation on contractual parties. The results for construction companies under three different sub-sector are presented, and the pattern of liquidation, their effects and status of the payments are generally similar.

The findings of the investigation indicate that insolvency payment effects remain prevalent in the construction industry; 70% of construction companies that failed went into liquidation within nine years of their incorporation; and that only 70% of the creditors of these companies have been paid. It was observed that financial losses to creditors of liquidated general construction companies were more than those of construction trade services companies and property developers. It can be concluded that construction company cash flows are not properly managed when compared to construction trade services companies or property developers, or that construction companies lack control of payment terms and sourcing of funds (probably due to poor reconciliation processes). It can also be concluded from this study that unsecured creditors within the construction company supply chain are the worst hit by liquidation.

It is recommended that payment clauses within the Construction Contracts Act should be enforced in New Zealand to serve as financial protection mechanism for construction companies. Also it is useful to re-establish contractual and regulatory provisions for prompt settlement of payment claims on construction projects. These will cause a culture shift that could improve the overall image of the construction industry. Proper processes for cash flow reconciliation on projects are recommended within constructing organisations as preventative measures against liquidity problems and consequently liquidation. To protect trade creditors, it is recommended that contractual provisions that allow for prequalification of principals, could assist unsecured trade creditors who have been found to be worst hit when things go wrong financially.

Finally, it is proposed that further studies should be carried out to examine case studies that could validate the inferences made in the current study investigation. Problems surrounding business insolvencies are significant in the construction industry, thus more research efforts that could proffer feasible solutions to the problem cannot be overemphasised.

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Integration of BIM and e-procurement in the Construction Industry: a Systematic Bibliographic Review

SCHAKER, Felipe R. C.; SANTOS, Adriana P. L.

ABSTRACT

Purpose of this paper

The procurement process virtualization, especially as e-procurement platforms, tend to reduce transaction costs and expand supply chains. Concurrent advances in information and communication technologies such as Building Information Modeling (BIM) have proved to improve the typically hindered information flow of the construction industry. The aim of this research is to assess the current state of the art of the integration of BIM and the e-procurement process.

Design/methodology/approach

This paper is the result of a Systematic Bibliographic Review (SBR). Through the application of a systematic method, it was possible to filter papers from four databases, find the most relevant researches and delineate the state of the art of the subject.

Findings and value

The correlation of fifteen papers revealed real possibilities of integration of BIM and e-procurement, but there are still various barriers to overcome, mainly about the civil construction industry fragmentation and the systems interoperability. The most advanced researches were developed in Portugal, where there is a strong governmental foment for the e-procurement utilization. It was verified the relevant role of the government in the implementation of technology innovation.

Originality/value of paper

The aim of this research is to delineate the state of the art of the integration of BIM and e-procurement. By systematically contrasting previous researches, it was possible to identify convergent concepts and gaps, which can be exploited by other researchers.

Conclusions: Great benefits can result from the integration of BIM and e-procurement, such as improve-
ment of information flow and reduction of the typical fragmentation in this industry. The feasibility of e-procurement platforms that run based on BIM model sharing is demonstrated in the researches addressed in this review. However, few emphasize the barriers that need to be overcome to the extensive use of the developed prototypes. The main barriers are the fragmentation of the industry and the lack of interoperability between systems. The role of the government is recognized as the most influential for the effective implementation of e-procurement platforms, even more than the role of the companies that will run this process.

**Keywords:** BIM. E-procurement. Systematic Bibliographic Review.

**1 INTRODUCTION**

The procurement processes in construction are conditioned to the nature of the usual information exchange process in this industry. Fragmentation and CAD drawing- and paper-based documentation hamper the procurement process, leading to extra costs for activities that could be avoided by the utilization of a more lean process. The great volume of elements and considerably specific projects also bolster the dependence on unstructured procurement.

Research on application of new information and communication technologies (ICT) exposes the possibility of combination of BIM and virtualization of procurement processes, which could reduce costs by improving the information flow and increase access to suppliers. This research delineates the state of the art of the integration of BIM and e-procurement.

**2 RESEARCH METHOD**

The research was conducted by the application of a bibliographic review. According to Webster and Watson (2002), this is an essential resource of any academic work. It consists of the survey, analysis and synthesis of publications relating to certain subject. Gil (2002) highlights the exploratory nature of the bibliographic review, which is developed based on previous researches, mainly books and scientific papers. Through bibliographic review, theoretical and scientific basis - the state of the art – of the subject to explore is forged.

Comfort et al (2011) contrast two types of bibliographic review. The narrative type consists of a simplified description of studies and definitions on a given subject based on material randomly selected by the author without well-defined criteria. It may result in excessively personal interpretations, with insufficient critical analysis. (Shaw, 1995. The second type is the systematic bibliographic review (SBR). Although SBR has also a narrative character, it requires the application of methods with more scientific rigor in the selection of bibliography.

The bibliographic review rigorous systematization enhances the achievement of better results, reducing the potential for error and bias of the researcher (Cook et al, 1997). With systematization, it is possible to identify gaps in the theory, which can be exploited by other researchers, but have not been identified in similar studies due to lack of rigor. (Conforto et al, 2011). Rigor also fosters more reliable results, producing, according to Webster and Watson (2002), a benchmark for the conduction of future research.
2.1 Tool

In this research, a SBR was performed by applying a tool based on the SBR roadmap method, presented by Conforto et al (2011), combined with the matrix of concepts presented by Webster and Watson (2002).

The aim of the tool application is to find papers with relevant approaches on the subject under study. There are three stages – input, processing and output – divided into steps. The SBR Tool is illustrated in Figure 1.

2.1.1 Stage 1: Input

- Problem: the problem definition is the starting point of the SBR. The problem of this research is: “What is the state of the art of the integration of BIM and e-procurement in construction?”.

- Objective: must be clear and feasible. Here, the objective is to define the state of the art of the integration of BIM and e-procurement in construction through the description of concepts raised in related research.

- Primary sources: databases to be explored in the search. Due the relevance of their publications in the research area, four databases were selected: Science Direct, Web of Knowledge, Scopus and Periódicos.Capes. The search was restricted to papers that had been published in journals or presented at conferences.

- Search Strings: keywords and their combinations and the search rules. The keywords combinations were: (a) e-procurement, BIM; (b) electronic, procurement, BIM; (c) electronic, marketplace, BIM; (d) online, commerce, BIM; (e) cloud, procurement, BIM. All searches were restricted with the Boolean operator AND, so the resulting papers contained all keywords of each combination.

- Inclusion and qualification criteria: must take into account the research objectives. Papers to be qualified as results of the SBR should not necessarily address the problem directly, but to substantially contribute to its resolution. This can then be verified with the assessment of the articles through the matrix.
concepts described in stage 2.

- Method and Tools: bibliographic review was the applied method and SBR was its tool. After the collection of the first papers, the next step was to seek the elimination of repeated results. Non-repeated items were subjected to the first filter: reading of title, keywords and abstract. Articles with identified relevance were then subjected to the second filter: reading of introduction and conclusion. When relevance was confirmed, the article was approved for the analysis of results.

2.1.2 Stage 2: Processing

A matrix of concepts was developed for the analysis of results. This is the identification of the concepts covered by each approved paper and conception of a matrix by linking the concepts of the various papers. Thus, it was possible to identify the most common concepts, indicating the common path of research. The search results was documented by registration of titles, authors, year and journals and/or congresses and also the filter status (approved or rejected). This document is an appendix to this article.

2.1.3 Stage 3: Output

Stage 3 consists of paper registration and archive and finally the synthesis of the results. Webster and Watson (2002) propose the discussion of each concept identified in the matrix and its logical grouping. The results are discussed below.

3 RESULTS

247 papers resulted from the first search, which is detailed in Table 1. Science Direct platform has provided that most of the results (82.99%). The other three databases totalized only 17.01% of the results. Web of Science provided only 3.64% of them. The keyword combinations had more balanced results. Among them, the combination (b) electronic, procurement and BIM was the one that provided more results, 34.41% of them.

<table>
<thead>
<tr>
<th>Keywords</th>
<th>Science Direct</th>
<th>Scopus</th>
<th>Web of Science</th>
<th>Periódicos Capes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>e-procurement, BIM</td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td>29 (11,74%)</td>
</tr>
<tr>
<td>electronic, procurement, BIM</td>
<td>72</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>85 (34,41%)</td>
</tr>
<tr>
<td>electronic, marketplace, BIM</td>
<td>26</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>30 (12,14%)</td>
</tr>
<tr>
<td>online, commerce, BIM</td>
<td>57</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>60 (24,29%)</td>
</tr>
<tr>
<td>cloud, procurement, BIM</td>
<td>35</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>43 (17,40%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>205</td>
<td>15</td>
<td>9</td>
<td>18</td>
<td>247 (100%)</td>
</tr>
</tbody>
</table>

247 papers resulted from the first search, which is detailed in Table 1. Science Direct platform has provided that most of the results (82.99%). The other three databases totalized only 17.01% of the results. Web of Science provided only 3.64% of them. The keyword combinations had more balanced results. Among them, the combination (b) electronic, procurement and BIM was the one that provided more results, 34.41% of them.
With the registration of the results, it was possible to delete repeated ones. The registration frame is exposed as an appendix. After the exclusion of repeated papers from the original 247 results, 159 papers were subjected to the first filter. From these, after reading of title, abstract and keywords, only 17 were qualified for the second filter. After its application by reading of introduction and conclusion, finally 15 articles were selected for analysis. From them, 12 were results from the Science Direct database, 5 from Scopus, 4 from Web of Knowledge and 8 from Periódicos Capes. All combinations of keywords had selected papers.

After the full reading of the 15 papers, the matrix of concepts was developed, as presented in Figure 2.

**Figure 2 Matrix of concepts**

<table>
<thead>
<tr>
<th>Authors</th>
<th>ICT in construction</th>
<th>Procurement / E-procurement</th>
<th>Verification of viability of the use of e-procurement in construction</th>
<th>BIM</th>
<th>Government initiatives fostering e-procurement</th>
<th>Cloud computing</th>
<th>Interoperability</th>
<th>Projects of BIM and e-procurement integration</th>
<th>Total</th>
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<tr>
<td>Grilo e Jardim-Gonçalves (2009)</td>
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<td>Ajam et al. (2010)</td>
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<td>Grilo e Jardim-Gonçalves (2011)</td>
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<td>Tran et al. (2011)</td>
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<td>Ren et al. (2012)</td>
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<td>Redmond et al. (2012)</td>
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<td>Costa e Tavares (2012)</td>
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<tr>
<td>Grilo e Jardim-Goncalves (2013)</td>
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<td>Porwal e Hewage (2013)</td>
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<td>Costa e Grilo (2014)</td>
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<td>Chong et al. (2014)</td>
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<td>Ibem e Laryea (2014)</td>
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<td>Ciribini et al. (2015)</td>
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<td>Naoum e Egbu (2015)</td>
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<td>Li e He (2015)</td>
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<td>Total</td>
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<td>13</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

**Legend:**
- Concept verified
- Concept not verified
The most frequently observed concepts are BIM and procurement / e-procurement. That is reasonable since these concepts correspond directly to the objective of the research. Interoperability is a problem that several authors have identified on the integration of BIM and e-procurement. This concept is the third most observed, together with projects of BIM and e-procurement integration. Then come the concepts of ICT in construction and government initiatives fostering e-procurement, both were identified in almost half of the papers. The cloud computing concept was observed in one third of them. Finally, only one paper addressed notably the concept of verification of viability of the use of e-procurement in construction. This is a negative revelation, since the studies may take into account assumptions that could be rejected by this concept.

Regarding to the geographical distribution of the publications, one third of them was carried out by a group of authors from Portugal. This concentration occurred because of the government incentives in this country for the use of public e-procurement. 9 from the 15 papers were produced in Europe, possibly because of its public regulations tending to the use of BIM and e-procurement.

4 CONCEPT DISCUSSION

Each concept was individually discussed below, with highlight of the most relevant information from the papers.

4.1 Information and Communication Technologies in construction

The Building and Construction industry is the major sector in which ICT is fragmented. The diversity and heterogeneity of systems and applications in place is large, making a scenario of strong intra- and inter-enterprise interoperability challenges. (Grilo and Jardim-Gonçalves, 2009). These authors indicate that, even with the domain of large companies, the dependence of small and medium enterprises (SME) is large. According to Tran et al (2011) the SME often have a low degree of maturity to adopt, use and benefit from ICT, such as e-commerce.

Grilo and Jardim-Gonçalves (2011) explain that the construction industry is characterized by the procurement of unstructured goods and services, which makes the use of systems for this activity more difficult. This difficulty is reported particularly when the information necessary for contractual arrangements is not properly structured and is in a digital processing format. Usually the quantification of resources necessary for a project is based on CAD drawings. In cost estimate, Ren et al (2012) described the vulnerability of traditional quantifications to human error and its spread.

4.2 Procurement / e-procurement

According to Mohsini (1993) apud Ibem and Laryea (2014), procurement is a process involving a sequence of decisions and/or actions that a client engages in as soon as the need to acquire a new facility arises. These authors also cite Alarcon et al (1999) and their statement that in construction, these needs are to supply equipment, materials and other resources required for the implementation of a project, including the execution of bids and/or opening of competition for execution of services or delivery of products. Grilo and Jardim-Gonçalves (2011) point out that the scope of the procurement is broader than the pur-
chasing process, as it involves strategic activities such as negotiating with suppliers and coordination with the research and development sector.

Grilo and Jardim-Gonçalves (2011) divide the procurement in two phases: contracting and settlement. Contracting, in turn, is divided into sourcing and availability to promise. Sourcing is the search for request information of products and services. Availability to promise is the flow of information with a supply chain, i.e. the availability of goods and delivery arrangements. This information flow is usually generated by the quotation and negotiation functions. The settlement phase is divided into transaction and delivery. Transaction is the payment of goods and services and delivery is its movement from seller to buyer.

Grilo and Jardim-Gonçalves (2011) describe also both types of procurement: structured and unstructured. Structured comprises a regular supply demand without changing specifications over time. A procurement process can be designed with more accuracy and long-term relationships with suppliers, which can reduce transaction costs. However, construction processes also require products with highly irregular demand and high variable specifications. They generate customized needs and potential uncertainties, demanding procurement activities not covered by already defined and/or automated procedures, which can lead to high transaction costs for the acquiring company. This is the unstructured procurement. In each civil engineering product there is always need to purchase products and services with great standardization and routine use, particularly during the construction phase. However, many activities relate to the procurement of highly unstructured supplies, such as specialist subcontracting services and even one-off non-standardized construction products and equipment. (Grilo and Jardim-Gonçalves, 2011).

Ajam et al (2010) indicate that the prevailing method of communication on procurement in construction is still based on paper due to legal restrictions and/or cultural or organizational defects. These authors also highlight the lack of quality control procedures and/or incompatibility of procedures between the various parties involved, as well as lack of integration of the information used by the various parties in construction bidding. Porwal and Hewage (2013) reported that the traditional method of procurement has been criticized for separating the design and construction processes, which obstructs the communication and coordination between teams responsible for these activities.

Ajam et al (2010) indicate that communication, location, timing and control may be facilitated by the use of ICT tools forming virtual collaboration extranets to add value throughout the construction industry. In the procurement process, these authors list as potential benefits of these extranets time and cost save, improving communication between team members, contributing to the building of trust and transparency, the base of knowledge and organizational learning, better services and greater engagement with clients.

Grilo and Jardim-Gonçalves (2011) reported that the structured procurement has been the main target of existing procurement electronic platforms such as e-procurement systems and virtual marketplaces (e-marketplaces). The e-procurement systems seek to bring to virtual and shared environment the procurement processes that traditionally rely on paper documents and occur in a fragmented way. E-marketplaces are virtual spaces in an electronic network that provide buyers and sellers opportunities to exchange information on prices and product offerings, and an electronic trading platform. These spaces aggregate information from different suppliers and buyers. From the e-marketplace service provider perspective, each client, remotely and through the Internet, can have as many e-marketplaces as they need,
and each client or each project is likely to have its own e-marketplace (Grilo and Jardim-Gonçalves (2013). These systems have proved to provide positive impacts in the supply chain management and the range of benefits is diverse, from simple operational cost benefits to more strategic benefits like improvement of flexibility and responsiveness (Grilo and Jardim-Gonçalves, 2011).

The conventional phases of e-procurement listed by Costa and Grilo (2014) are:

(i) ex-ante e-evaluation: refers to multicriteria evaluation of needs and procurement strategies;

(ii) e-noticing: concerning electronic publication of public procurement notices;

(iii) e-submission: concerning electronic submission of proposals;

(iv) e-decision: concerning electronic evaluation of proposals, subsequent communication of evaluation results, and discussion and analysis of results;

(v) e-award: concerning electronic contract awards to suppliers with the best proposals;

(vi) e-ordering: concerning all activities, including sending an order document from public buyers to suppliers, to the transmission of delivery instructions for ordered goods and services;

(vii) e-invoicing: concerning claim for payment for goods and services ordered and delivered under agreed upon conditions;

(viii) e-payment: agreed electronic payment management and execution;

(ix) e-contract management: refers to the use of electronic contract management instruments to monitor and improve contract performance and document management;

(x) ex-post e-evaluation: agreed multicriteria evaluation of the contract execution, and the eventual generation of KPIs to support future tendering processes.

According to Costa and Grilo (2014), in a fully integrated environment and without the use of printed documents, all these processes should be combined and all relevant information should be available electronically. Ibem and Laryea (2014) list as benefits of using ICT tools in procurement of construction projects the increased project quality, cost reduction, user satisfaction, increased responsiveness and productivity, market expansion and the effectiveness of project delivery.

4.3 Verification of viability of the use of e-procurement in construction

Most authors do not stuck in assessing the ability of the construction industry for the implementation of e-procurement. Some of them make brief remarks about the difficulties that the sector companies face in virtualization these processes, but only Tran et al (2011) addressed the issue systematically.
Tran et al (2011) define the ability of a company to implement e-procurement as its propensity in relation to e-procurement (perception of managers on e-procurement, history of successful implementation of a new operation or management philosophy) and its available internal capacity to implement and get noticeable benefits (human, technological and business resources). For these authors, the nature of aptitude is dynamic, i.e. it may increase or decrease with time. To measure it, they propose a structure that covers governmental, technological and business influences.

According to Uzoka et al (2007) apud Tran et al (2011), the role of government is to guide and support the adoption of innovation through its policies, regulations and benefits. The adoption of a national vision focused on modernization through e-procurement in the public sector boosts the private sector in the same direction. This includes not only the establishment of e-procurement for public acquisitions, but also efforts for training and education of professionals and directing funds for research in the area. Alzougool and Kurnia (2008) reported that in developing countries, the adoption of e-procurement has been conditioned by the quality, availability and cost of access to technology infrastructure. The management of the government’s technological infrastructure can also affect this adoption by the private sector. For Tran et al (2011) within the organization, since the highest levels of the hierarchy must have engaged perception and attitude toward e-procurement. Each type of business has different relationships with clients, contractors, consultants and suppliers, and the barriers to e-commerce are different according to each type and organizational culture. Tran et al (2011) conclude that the role of government in the ability level for implementation of e-procurement has more influence than the company itself.

Wong (2007) reported that there are cases where the adoption of virtual collaboration extranets in fact further complicates the communication process. Grilo and Jardim-Gonçalves (2011) mentioned that the positive or negative impact of e-procurement depends on the characteristics of the product or service, and that it may not be suitable for some goods or services with high specification, in which close relationships between buyers and suppliers are essential. For these authors, this may be the case in the construction sector, in which many of the goods and services have complex levels of specification.

4.4 BIM

The internal dimension of ICT in the construction sector has evolved strongly related to technical design and engineering applications. (...) It has become possible to enrich the 3D models of buildings and structures with complementary data such as physical characteristics, unit costs, quantity take-offs, etc. (Grilo; Jardim-Gonçalves, 2009). This evolution is designated as the Building Information Model or Modelling (BIM). Grilo and Jardim-Gonçalves (2011) explain that BIM enables the creation of a composite model, in which the various specialties of a project can contribute interactively to build a model. With this, Ren et al (2012) complete that it is possible then to store and extract model information such as specifications and operational requirements. When this information is updated or there are changes in any view of the model, automatically the whole model and its views are updated. According to Ren et al (2012), the advantages over traditional systems based on drawings are minimizing manual work, facilitating communication, coordination and collaboration, reducing time and cost, resulting in fewer misunderstandings between parts, providing even greater accuracy in procurement processes.

For Redmond et al (2012), this is a turning point, since this is not the automation of established processes, but the automation of synchronization of information across applications to speed workflows. This
approach focused on the process level became the best practice recognized by the class, according to Grilo and Jardim-Gonçalves (2009). These authors made clear, however, that interactions involving components of models created by different software require interoperability, which becomes even more important when used in virtual platforms, such as e-procurement. Grilo and Jardim-Gonçalves (2009) also point out that the interface with the BIM introduces a new layer of complexity, mainly due to the heterogeneity of systems and applications.

4.5 Government initiatives fostering e-procurement

Tran et al. (2011) report that in developing countries, the construction industry is characterized by small and medium companies, which often have a low level of ability for adoption and use with benefits of ICT, such as e-commerce. Thus, supportive regulations, legislation and government policies are considered very important in the adaptation and implementation of e-procurement.

Grilo and Jardim-Gonçalves (2009) present the Single European Electronic Market (SEEM) as a contribution to the vision of the Single European Information Space (SEIS) a structured space based on the Internet, where companies can access a lot of information already available on various portals and corporate databases and use them for collaboration purposes. The focus of the implementation of the SEEM is basically linked to small and medium enterprises, which are still marginal to electronic commerce. For them, the SEEM vision is achievable with the appropriate provision of adequate Internet applications to manage processes, hiding the complexity of the technological infrastructure through simple interfaces and ensuring the interoperability of systems. In compensation to the database access, the condition for entry and operation in the market is to regularly upgrade and improve this database by companies.

In Portugal, e-procurement has become mandatory for the public sector with the Public Contracts Code adopted in 2008. (Costa and Grilo, 2014; Costa and Tavares, 2012). The authors explain that, since then, significant improvements have been achieved by the use of electronic platforms, which proves that a considerable reduction in operational efforts is possible. Then, Costa and Tavares (2013) state that gradually the private sector recognizes its benefits and implement e-procurement. In the UK, all public projects should be in BIM by 2016 (Porwal and Hewage, 2013).

4.6 Cloud Computing

Grilo and Jardim-Gonçalves (2009) described the cloud computing as a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet. Chong et al (2014) identify it as an advanced technology in which hardware and software are available as a platform for collaborative services over the net. These authors state that users do not need to have the property nor even the knowledge about the technology infrastructure that supports these cloud services, but also have no control over it.

Because of its flexibility and scalability, Grilo and Jardim-Gonçalves (2009) and Chong et al (2014) agree that cloud computing reduces the price of access for small and medium-sized enterprises to a digital infrastructure before only accessible by large organizations. Grilo and Jardim-Gonçalves (2009) add that the emergence of this concept can release companies from the complexity of ICT, which is a promising step in the development of electronic platforms.
Redmond et al. (2012) conducted a research with experts who apply cloud computing combined with BIM and found that the main barriers identified by them for using a cloud platform are problems in the security of data and legal issues such as data ownership. Then there is the problem of connectivity, as some building sites are located remotely with no Internet access. On the other hand, the combination of BIM and cloud computing is associated with the efficiency due to cost reduction, leading to the integration of several disciplines.

4.7 Interoperability

According to Grilo and Jardim-Gonçalves (2011), e-procurement presents several technical challenges that create interoperability problems. These authors cite the example of European public procurement procedures, which require the submission of certificates and attestations from companies to prove compliance with the criteria for selection and exclusion. The interoperability required between electronic certificates has caused operation problems.

Ren et al (2012) and Grilo and Jardim-Gonçalves (2010) reported that since the early 90’s, there are efforts to develop standards for the definition of interoperability between BIM models. This means that it is necessary for all of them compatibility with models created by other softwares, so that all information objects can be correctly transferred. In most cases, it is a challenge for such translation to retain all the information contained in the model in its original file format. Despite the efforts from several companies to develop interoperable software, Grilo and Jardim-Gonçalves (2010) reported that most of the BIM applications of modeling and their complementary software tools address interoperability only among themselves, and not in relation to other vendors’ applications.

Grilo e Jardim-Gonçalves (2011) added that the interoperability problem becomes even more acute when a combination of BIM functions with traditional e-procurement in virtual platforms is desired, in which objects (such as windows, doors, pipes, etc.), and 3D parametric information should contain request for proposals, orders and invoices. Porwal and Hewage (2013) defined that the cloud-marketplaces system architecture (different e-marketplaces integrated in cloud) should support interoperability between e-marketplaces located on heterogeneous platforms and with other application systems available on the network. Interoperability between platforms will allow the flow of trade opportunities between them and eventually electronic transactions.

4.8 Projects of BIM and e-procurement integration

The obligation of e-procurement in the public sector in Portugal led it to be a pioneer country in integrating BIM to this practice. Grilo and Jardim-Gonçalves (2009) developed a model for e-procurement in which BIM is used from the first preliminary design of a project. In this model, after setting initial specifications through an application based on BIM, the initial program can be exported to a cloud platform. Then a generic model that will be the basis for the next stages is created in the next phase, architects can import the conceptual model and refine its details. The model can be exported thereafter again to the cloud, where a compliance test can be run between the received model and the original one. Until this point, it would not be necessary to connect to the network, but with the evolution of the project and the involvement of more professionals for specialized projects, more complex interactions occur. From then
the competition for the preparation of projects may begin, and so do the flow of commercial and managerial data. After updating the model, new compliance testing must occur. This model assumes that the BIM model would be the basis for transactions throughout the project life cycle and would be enriched always when an exchange occurs. Whenever a need for a service would emerge, it would be triggered on the cloud, where transactions would occur regardless of the physical location of stakeholders.

Grilo and Jardim-Gonçalves (2011) evolved into a case study with a project called PLAGE, a partnership between the Portuguese government and companies that develop software. One of the major issues of this project was to eliminate as much as possible of unstructured information from e-procurement process. In the created platform, it is possible to incorporate objects from virtual catalogs into the file during the detailing phase of architectural design. It is possible as well to link information not per se model objects, such as PDF files or Internet links, but each element shall be related to a BIM model object. In their study, only the design phase has been validated on the platform, the execution was not carried out.

Ren et al (2012) devised a basic structure of BIM and e-procurement integration and proposed tools for its implementation. In this structure, the general contractor is responsible for system operation and control. The responsible should store the initial BIM model in the system. This model is enriched then, and the quantification of the material and a cost estimate proceeds. The work schedule should also be stored and updated. With that information, contractors can release requests for material supply proposals. As tenders come, the contractor can observe the supplier performance history to choose the winner. The contracts would be managed through the system and the information would be available to those who need it.

Grilo and Jardim-Gonçalves (2013) introduced the concept of Cloud-Marketplace of Vortalway (an industrial research and development pilot project conducted by Vortal – at that time the leading e-marketplace company in Portugal and third largest in Europe in the field). The application and submitting of tenders scenario was tested in an environment that allows the connection of multiple heterogeneous electronic platforms, which is illustrated in Figure 3. To make it possible, support for transactions across platforms is necessary, as well as dissemination of opportunities and data flow management, among other interoperability activities. The suppliers markets are in Vortalway community platforms (Vortalway_OFFICESUPPLY and Vortal_ECONSTROL) and in external e-marketplace platforms. In addition to the designs and specifications, this platform offers the documents necessary for the competition based on BIM-IFC/STEP standards, as well as models for responses of competitors. In this process, additional information may be added, like expected execution dates, upper acceptable price and selection criteria. However, this information is incorporated into the bidding documents through a structured procedure that also feeds the original BIM model.

When users who are in Vortalway community respond, the platform automatically sends this response to the requester. When users are out of this community, the process takes place in its corresponding platform, but Vortalway delivers the response. The authors conclude that there are still challenges of interoperability between platforms. Vortalway supports it, but other e-marketplaces do not, unless they begin to get adapted specifically to accept access.
Costa and Grilo (2014) conducted another case study in PLAGE platform. A reform and expansion project of a school had design and part of its procurement process simulated. A BIM modeling software, the PLAGE platform and the management software PRIMAVERA were integrated. After the creation of the model in the modeling software, it was released in the e-procurement platform. The platform server sent the information of each component of the model to the management software, which linked activity information for each component. This information returned to the PLAGE server, and the model was updated. From then, requests for quotation were created by selecting of model components. Suppliers could answer the requests by the fulfilment of a form with price information or by attaching external files to components. The received proposals were then evaluated with a multicriteria evaluation tool provided by PLAGE platform. The authors concluded that this method should facilitate information management activities, as the BIM model would be the sole repository for project, contractual and administrative documentation. Incompatibilities should also decrease with the concentration of information in the model. However, these benefits may not justify the high costs of the additional efforts needed for the elaboration of the BIM model and consistently maintenance of the e-procurement process. This requires specialized support for the uniform treatment of information. It is also necessary deep knowledge about the creation of models. Thus, this process was not more agile than the traditional e-procurement. Problems with the conversion of individual building objects in blocks for applications also occurred. Again, interoperability has been identified as a problem, with the need for adoption of standardized solutions among stakeholders.
5 CONCLUSION

Although being object of only few researches, integration of BIM and e-procurement can result in great benefits to the construction industry, such as improving the flow of information and reducing the typical fragmentation of this industry. ICT developments supported the creation of new forms of business transactions. Through cloud computing, for example, smaller organizations have access to technology services equivalent to their needs, not massively investing in infrastructure and specialized service.

The researches addressed in this SBR demonstrate the feasibility of e-procurement platforms that run based on BIM model sharing. However, few researches emphasize the barriers that need to be overcome to the extensive use of the developed prototypes. The main barriers are the fragmentation of the industry and the lack of interoperability between systems. For the effective implementation of e-procurement platforms, Tran et al (2011) conclude that the role of government has more influence than the role of the company itself. This is verified by the fact that the most advanced research raised in this SBR are concentrated in Portugal, where public e-procurement is required.

6 REFERENCES


Using context factors to select historical information for cost estimating of construction projects

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ABSTRACT

More objective and consistent criteria for the selection of historical construction data to be used for estimating is needed. A methodology based on historical information, which incorporates qualitative context factors to the structure and use of historical information for cost estimating is proposed. A list of qualitative project context factors most influential for construction projects' cost and productivity is presented. Furthermore, a context model that includes these variables is described together with an explanation of how they can be incorporated into the cost estimate. It is concluded that with the incorporation of qualitative context factors, the use of historical information for cost estimating can be improved and that most critical aspects to achieve this feature are the creation of a reliable site-work feedback system and the correct structure of historical information.

Cost estimating; critical cost factors, historical information, context

1. Introduction

Existing estimating models have shortcomings in the management of available historical data. The cost and the justification of the time and resources to support the process of collecting, reviewing and organizing data in a project can be a significant challenge for many organizations (Figueiredo and Philipenko, 2010), so eventually the decisions are taken based on the criteria and experience of each estimator. Therefore, there is the need of defining objective and consistent criteria for the selection of appropriate historical construction data to be used for cost estimating. Then, a methodology based on historical information, which structures and incorporates qualitative context factors such as complexity, soil conditions and characteristics of the workforce of the project is proposed in this work.

A list of qualitative context factors and sub factors most influential in construction projects' cost has been constructed. Using these factors and sub factors, a model to define the actual context of a construction project has been created. Finally, an initial approximation to a method that integrates the proposed context model and a criterion for determining similarity between projects, into the cost estimating of construction projects are described.
2. Background

The estimation by analogy is a cost estimation method commonly applied which is based on being able to determine historical cost of activities or items and use them as references to predict costs of new activities or items proposed (Greves and Joumier, 2003). Therefore, a primary consideration for its use is to be able to determine the differences between current and past items or activities to estimate (Greves and Joumier, 2003), because from this will depend the required adjustments. This process of comparison between a construction project and another becomes complex when considering the incredible degree of customization and flexibility that the industry offers the consumer (very few products are so targeted to meet the desires of a particular consumer as construction projects) (Sawhney et al., 2004).

Many authors propose a list of variables that affect the productivity and costs of construction projects as shown in Table 1. However, studies indicate that time and cost prediction techniques used in the construction industry have shortcomings regarding the lack of incorporation of qualitative variables to the estimation process and the lack of definition of criteria for the selection of the relevant historical data. This may be explained because qualitative aspects are difficult to evaluate (Elhag and Boussabaine, 1997) and because the time and resources to support the process of collecting, reviewing and organizing the project data can be a significant challenge for many organizations (Figueiredo and Philipenko, 2010).

3. The problem

The quantitative knowledge is defined as cost elements and known structures of elements that form the basis of a cost estimate and are measurable (such as number of parts or types) (Rush and Roy, 2001). The qualitative knowledge is defined as the assumptions and judgments that cost estimators and engineers do during the generation of an estimate. These assumptions and judgments are related to how an estimator refers to past projects as a basis for the generation of a new estimate (Rush and Roy, 2001). The problem is that cost prediction techniques in the construction industry only consider relevant factors that can be calculated in numbers. Since most of the critical factors that affect project costs are of qualitative nature, estimators do not have all the relevant information related to past projects nor have a defined or applied selection method or a formal set of these, and for these reasons, they carry out a subjective assessment of the observed situation (Kisiltas y Akinci, 2009).
Table 1 Methodologies for estimating by analogy and its main shortcomings

<table>
<thead>
<tr>
<th>Author</th>
<th>Description of the estimation methodology</th>
<th>Shortcoming in relation to the selection of relevant information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proverbs et al (1999)</td>
<td>Method for estimating labour requirements and costs for international projects. Is based on determining labour productivity rates per area for concrete activities on site.</td>
<td>Productivity differentiation criteria only based on each country surveyed.</td>
</tr>
<tr>
<td>Yu (2006)</td>
<td>Model for conceptual cost estimation of construction projects (PIREM) that integrates several methods. The main cost items are modelled by a nonlinear parametric function.</td>
<td>Key parameters of the cost equations are only aspects of the project as superstructure type, foundation type, length of the stack, and so on.</td>
</tr>
<tr>
<td>Huang, and Wang (2008)</td>
<td>Costing methodology for construction projects, which integrates rough set (RS), and Artificial Neural Network (ANN). RS is applied to find the relevant factors of cost, to be used as inputs in an ANN to predict the cost of a project.</td>
<td>The models are made mostly with quantitative variables of project design: total height, area, type of structure, level of project management, period, underground area and level of project management.</td>
</tr>
<tr>
<td>Chon (2009)</td>
<td>Web-based CBR system applied to early cost budgeting for pavement maintenance project. Compare the historical data, item-level work through a library of cases.</td>
<td>The similarity between projects is based on quantitative factors, mostly, except project location and terrain (flat, hill or mountain). Applicable to a single type of project.</td>
</tr>
<tr>
<td>Rush and Roy, 2001</td>
<td>Model to estimate project costs through the use of expert judgment and analogy. Model the steps that make up the reasoning process used by an expert to make a cost estimate.</td>
<td>Indicates that the analogy is based on similar projects, which lists aspects that are usually used, but does not specify the most relevant and how to determine the similarity. Authors recommend research on how to make comparisons between projects.</td>
</tr>
<tr>
<td>Mohamed and Celik, (2002)</td>
<td>Knowledge-based integrated system for cost estimates and construction programs. Users enter general information about the project, select types of materials and evaluate productivity factors indicated.</td>
<td>With these productivity factors related to the project context, it affects only the duration of the project. The estimated cost only depends on design parameters, quantities, unit prices and materials.</td>
</tr>
</tbody>
</table>

The research question was stated as: how to determine, in a consistent and objective way, the performance to be used for activities under different conditions or contexts, on the basis of historical construction projects' data? The hypothesis is that it is formally possible to incorporate qualitative aspects of context in estimating the cost of a construction project, based on the structuring and use of historical information.

4. Methodology

The methodology used was to carry out a comprehensive literature review initially on the following topics: a) cost estimation methodologies based on the use of historical information, b) factors that affect the performance and productivity, and that cause overruns or inaccuracy in construction projects, c) methods for determining the similarity between projects. Through an arrangement, classification and application of the criterion of affinity, a list of 33 factors of 26 authors was obtained. These factors are shown in Figure 1.
Fig. 1 Factors affecting the cost and productivity of construction projects

Subsequently, and with the aim of focusing the study on the most relevant factors, a frequency study by author and a Pareto analysis were applied, obtaining six main factors in this way. To validate these factors, semi-structured interviews with nine experts in the area of cost estimation of construction projects of engineering and construction Chilean firms were conducted. These nine experts from nine companies selected only five of the principal factors as described in Figure 2. In addition, a list of the main sub factors to consider for each factor and the variables that determine the possible conditions was obtained.

5. Context Model

A Context Model was created to define the context in which a construction project develops. The model is defined by a matrix of factors and sub factors and the conditions associated with each one of the sub factors. The 15 context sub factors are qualitative variables, and their values are definitions of possible conditions. These definitions were built in base of the information gathered from interviews. The purpose is to provide information about a context that it is too complex normally or ill defined with a conventional description in quantitative terms (Baloi and Price, 2003).

To define the context of a project (historical or to be estimated), the estimator must select the alternative condition for each sub factor that best represents what happened or what is expected to happen. Every alternative condition has a positive integer associated with it, necessary to calculate the similarity. For each sub factor, conditions are ordered for most to least favourable and numbers are assigned starting at 1. To better visualize this, an example of variables and alternative definitions of condition are performed for contextual sub-factors (see Table 2).
6. Methodology for incorporating qualitative factors to the estimation of costs

The proposed methodology defines how to structure the historical project information, how to select the most relevant historical project information to the estimation of the new project and finally, how to apply this information to estimate the new construction activities yields. This methodology is based on: 1) the structure of the historical project information and 2) the processing and delivery of information (see Figure 3).

<table>
<thead>
<tr>
<th>Sub factor</th>
<th>Variable</th>
<th>Possible conditions (in order from worst to best)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of innovation of the project</td>
<td>Innovation of design, materials, technology or methodology of the project in relation to the company or the market in general</td>
<td>Project design, materials, technology or implementation methodology are very different from those made by the company or the industry in general, so it's pretty difficult to get staff with the appropriate knowledge or to reuse past experiences. Project design, materials, technology and methodology with some novel features and similar to those made previously by the company or industry in general, it is necessary to search for experts only for some subjects, and past knowledge is available for reuse in multiple aspects. Project design, materials, technology and implementation methodology quite similar to others conducted by the company or the industry in general, so there are many experts available and you can reuse past knowledge in most of the components of the work.</td>
</tr>
</tbody>
</table>

6.1. Structuring of the historical project information

The organization must provide feedback to a database that comprises three main types of relevant information:
- Overview of the project: project name, client, contract type, estimated and actual date of start and end, and location. The estimator can add the information as deemed necessary.

- Background information for the project: context associated with the execution of each project through the defined Context Model.

- Activity-based costing information: size of the activity and amount of resources required (both with their unit of measurement). This will determine the yields associated with resources and not with price, since they vary over time. The unit price of each resource must be entered each time the estimator performs the cost estimation.

On the other hand, the estimator should define settings to the proposed generic context model, in order to focus on the types of projects that are carried out by his/her company. These adjustments relate to:

- Factors: remove, add, or decomposed sub factors or contextual factors.

- Conditions: make clear the definition of possible conditions, add new conditions, and take out those that do not apply, or break the existing ones into more detail.

![Fig. 3 Application of the proposed cost estimating system](image)
6.2. Processing and delivery of information

The processing and delivery of information is mainly based on the use of a similarity criterion between construction projects to define a method of historical selection of projects, which are more alike to the project to be estimated (see Figure 4). The adjustments required from the estimator are to:

- Define the relative weights of context factors and sub-factors, necessary for the application of the criterion of similarity between projects.
- Carry out the design review and adjustments as required (contents and format).
- Define the minimum similarity value required for the project to estimate and historical projects (historic projects with lower overall similarity that the limit indicated, should not be considered for the estimation of costs).

Fig. 4 Processing and information delivery of the proposed cost estimating system
6.3. Similarity criterion between projects

The determination of similarity between projects is based on the criteria used by Serpell (2010) and Chou (2009), where the overall similarity is built on a number of called local similarity functions, one for each attribute describing the project involved. Thus, the overall similarity between two cases is calculated as the weighted sum of local similarities.

For the proposed system, the Local Similarity (between sub factors) is determined first, then the Global Similarity (between factors) and finally, the Project Similarity (between projects).

- **Local Similarity (at the level of contextual sub-factors):**

\[
\text{Local Sim} (P_{ij}, Q_{ij}) = 1 - \frac{\text{dist}(V_{Pij}, V_{Qij})}{R_{\text{max}}} 
\]

(1)

- **Global Similarity (at the level of contextual factors):**

\[
\text{Global Sim} (P_j, Q_j) = \sum_{i=1}^{n} wsf_i \times \text{Local Sim} (P_{ij}, Q_{ij}) / \sum_{i=1}^{n} wsf_i 
\]

(2)
• Project Similarity (at the level of project):

\[
\text{Project Sim} (P, Q) = \frac{\sum_{i=1}^{n} w_{fi} \times \text{Global Sim} (P_i, Q_i)}{\sum_{i=1}^{n} w_{fi}}
\]  

(3)

\( P \) = Input project (to be estimated).
\( Q \) = is a project of the historical database.
\( n \) = the number of contextual factors (5 generics).
\( i \) = is a single factor from 1 to \( n \).
\( w_{fi} \) = is the relative weight of the factor of context \( i \). Project Sim = the similarity function between projects.

6.4. Reporting of information to the estimator

The methodology recommends the development of two types of reports: 1) Reports required to estimate the costs of a new project, and 2) Reports for subsequent analysis at the end of a project.

- To estimate yields: Historical Projects Preliminary Report (historical projects in order of Project Similarity) and Yields Requested Activities Report (maximum, minimum and average yields on similar projects by activity, until the minimum Similarity value defined. From these, the estimator discusses and estimates the final yield of the activity for the new project, considering the following aspects: 1) Local and Global Similarity, indicating reasons and magnitude of adjustment in addition to the assessment context, which defines whether it is adjusting up or down, 2) Associated with the size of the activity and it is estimated. For a larger size of the activity, the average yield should be higher (learning by repetition).

- For further analysis: Report of comparison between the estimated and actual information (feedback for the Context Model and the proposed methodology).

7. Conclusion

This paper describes a study of the contextual factors that impact cost and performance of construction projects, understanding context as the characteristics of the situation in which projects are carried out. Throughout the study, the main achievement was in defining the main factors: project complexity, quality of project information, weather conditions, and characteristics of labor and site conditions. Through its utilization it was possible to define a context model for construction projects, which allows defining the context execution of the project, and a methodology to incorporate these qualitative factors for cost estimating.

The methodology defines how to structure, retrieve and use the available historical data, using an objective and consistent criteria to define similarity between contexts of construction projects. It is concluded that the incorporation of the qualitative context factors to the cost estimation process through the proposed system, could improve the application of historical information, as it allows: 1)
to identify, understand and structure those contextual aspects that have a critical influence on yields and costs, allowing to define which specific information is required for projects, 2) to establish and improve the selection criteria for relevant information within an organization, which involves minimizing personal biases in cost estimates, and 3) to maintain and increase the implicit knowledge of experts and past experience within the organization.

However, the most critical aspects for successful implementation of this methodology are the creation of a system of permanent monitoring, control and feedback of the results obtained, in addition to structuring and updating the historical data available (with new data and further adjustments required). The validation of the results obtained by applying the proposed system will be made in future studies, by an application to a company. For future research it is recommended to complement the Context Model with activity level factors in order to establish more detailed criteria of similarity.

8. References


Home Ownership Rates & Affordability – Global Comparisons

ABSTRACT

Purpose

This paper provides a comparative analysis of the rates of home ownership and the affordability of this home ownership around the world. In many countries home ownership has traditionally been a fundamental aspect of their societal fabric and is thus reflected in high rates of home ownership whilst in other countries home ownership is not considered as important with other housing tenure forms more widely used. The varying rates of home ownership amongst countries and the reasons for these differences will be explored.

The paper will then examine trends and differences in home ownership affordability in various countries. This will start with an examination of the various methods used to measure housing affordability. These methods can be broadly categorized as Accessibility/Deposit Gap Methods, Housing Costs – Income Ratio Methods, Median Income Multiplier Methods, Residual Income Methods, and Aggregate Economic Indicators/Indexes. It will then explore and compare the main global home ownership affordability measures used around the world.

Research Methodology

The research methodology is based on a review of global literature and data on home ownership rates and home ownership affordability measures and a comparative analysis of this literature/data.

Findings and Value

The research reveals that there are wide differences in home ownership rates and affordability around the world. In many developed countries where home ownership has traditionally been the preferred tenure form, the affordability of owning a home has declined markedly in recent years and is resulting in a generational change of reduced home ownership rates and moves to other tenure forms. For many of these countries, this is causing significant problems as these other tenure forms have not been well developed due to housing policies that have traditionally favoured home ownership. Conversely, the research found that home ownership rates in many developing countries are increasing as these countries experience considerable economic growth and increasing individual wealth providing the enabler for people to move into home ownership. A key finding was the importance of coordinated and strategic long term government housing policies to support these changes.
Research Limitations/Implications

Research into the link between home ownership, affordability levels and capital gains (profit) derived from home ownership would further compliment this study. In many countries, home ownership provides the main source of personal wealth. Accordingly, affordability issues may be offset, particularly for long term owners, through the financial returns on their home. This aspect was considered beyond the scope of the study as this would have required extensive research and analysis of residential property price movements.

Keywords: Home Ownership, Housing Affordability

1 INTRODUCTION

Home ownership is the dominant tenure form in many countries with home ownership rates accelerating around the world in the past few decades. It has the dual attributes of being both a consumption and investment good providing numerous societal benefits and the often the greatest source of building personal wealth. However, in other countries home ownership is not considered as important with other housing tenure forms more widely used. Accordingly, the level of importance of home ownership affordability will vary amongst countries. However, recent studies have shown that affordability levels are declining in many cities around the world due to a large number of interconnected and complex factors.

Affordable home ownership conveys the notion of reasonable housing costs incurred by home owners in relation to their income. Reasonable home ownership costs should leave the home owner (and their family/household) with sufficient income to meet other needs such as food, clothing, transport, medical care, education. In general, affordability definitions are based on the following three components: housing cost ratios against income, the appropriateness of housing and the adequacy of residual incomes after meeting housing costs. Few if any definitions effectively encompass all three components.

The individual preferences and needs of home purchasers and the amount they are prepared to spend on their housing in the short and long term are also important factors. “Housing affordability itself is a subjective term. It depends on individual circumstances, according to where people want to live and how much they are prepared to spend. For example, a family may be prepared to spend more than 30% of their income on their mortgage in order to pay it off quickly. They may choose to live in a relatively more expensive area to be close to work, their extended family, friends, or for other reasons, even if this requires higher rent or mortgage payments. They could then be classified as being unable to afford their house, though they have made the decision to have that lifestyle” Cardew et.al. (2002, p. 23).

They also highlight the different affordability thresholds for different households and stages of the life cycle. Single people may be able to pay higher proportions of their income for housing than households with dependent children. Dual income households could similarly afford a higher proportion of net income than single income households. This may particularly be the case where couples decide to pay a high proportion of their income on their mortgage repayments in the early years of ownership with the plan of reducing the principal component of their loan as much as possible prior to having children. Some households may have housing costs that would generally be considered unaffordable yet are in that posi-
tion by choice and adjust their lifestyle to ensure that their after-housing disposable income is satisfactory for their needs.

However, in addition to the financial burden being taken by these households, researchers are increasingly examining the impact that these choices have on lifestyle and other societal factors. Ambrose (2005) is one of many researchers who have identified the significant problems that financial over-commitment to housing is causing. These include deterioration in lifestyle generally, inability to participate in sporting and leisure pursuits, breakdown in the family unit, increasing use of childcare facilities as parents work longer hours to meet their mortgage commitments and even declines in quality of health as less money is available for health care.

The McKinsey Global Institute (2014, p.1) undertook a comprehensive assessment of global affordability problems and highlight the importance of the issue:

“We estimate that 330 million urban households around the world live in substandard housing or are financially stretched by housing costs. Some 200 million households in the developing world live in slums; in the United States, the European Union, Japan, and Australia, more than 60 million households are financially stretched by housing costs.

Based on current trends in urban migration and income growth, we estimate that by 2025, about 440 million urban households around the world - at least 1.6 billion people - would occupy crowded, inadequate, and unsafe housing or will be financially stretched.

The housing affordability gap is equivalent to $650 billion per year, or 1 percent of global GDP. In some of the least affordable cities, the gap exceeds 10 percent of local GDP”.

2 GLOBAL HOME OWNERSHIP AFFORDABILITY MEASUREMENT METHODS

2.1 Methods of Housing Affordability Measurement

Housing affordability measures are the main means of providing housing consumers and decision makers with information on housing costs and their affordability. A review of housing literature has shown that the concept of housing affordability is complex and that considerable disagreement exists amongst researchers and policy makers about how to define it. Adding to the problem is that affordability definitions are often twisted to suit the vested interests of policy makers, governments, lobby groups, industry organisations and researchers (Gabriel et al., 2005; Quigley and Raphael, 2004). A number of methods have been developed to measure housing affordability. The main methods used include:

- Accessibility/Deposit Gap Measures
- Housing Costs to Income Ratio Methods
- Median Income Multiple Method
- Residual Income Methods
- Aggregate Economic Indicators/Indexes
2.2 Accessibility/Deposit Gap Measures

This method measures the accessibility of home ownership – essentially the amount of money a potential purchaser needs to save to put a deposit on home and gain access to home ownership. The distinction between home ownership accessibility and affordability is important. The main constraint facing first home buyers and other purchasers with low savings and wealth is gaining access to home ownership; high capital costs, pre-purchase costs and limits on borrowing capacity all impinge on the ability of households to purchase a home. Affordability measures are irrelevant for households who have insufficient savings to purchase a home in the first place. The main variables used in this form of measurement are house prices, pre-purchase costs (such as stamp duty, legal/conveyancing fees, insurances), purchaser savings/deposit levels and the purchaser’s maximum borrowing capacity.

2.3 Housing Expenditure to Income Ratio Methods

Housing affordability benchmarks that measure housing costs as a ratio of income have traditionally been the most common method of measuring affordability (Ambrose, 2005). The conventional benchmark ‘rule of thumb’ is that housing costs should not exceed 25%–30% of a household’s income, approximately a quarter of a household’s income (Burke and Ralston, 2003). A key study on the housing expenditure to income ratio was carried out by Hulchanski (1995). He found that the 25% benchmark emerged in the 19th century based on the principle of “one week’s pay for one month’s rent” and quickly developed into the most commonly used affordability benchmark measure and remains so today.

However, Hulchanski argues that the conceptual, theoretical, empirical, methodological and practical problems with the ratio measure have never been resolved and considerable debate still exists in the housing research community about its use. He found that the measure lacks any scientific foundation and is fundamentally based on a ‘rule of thumb’ approach with grossly generalised assumptions about household consumption patterns. The main issues centre on the composition of housing costs (particularly the lack of comprehensive allowance for these costs) and income (particularly in terms of gross versus net income, fluctuations in income and differences in allowances for the varying contributors to household income). The key problem is that the method simply cannot account for the extremely diverse nature of household consumption (Hulchanski, 1995).

2.4 Income Multiplier Method

The Income Multiplier Method measures the ratio of average or median house prices to average or median gross or disposable income in a given geographical area. The median price ratio to median incomes is more commonly used than average prices/incomes (the Median Multiplier). Demographia (2016, p.1) note that the Median Multiple Method “is widely used for evaluating urban markets, and has been recommended by the World Bank and the United Nations and is used by the Joint Center for Housing Studies, Harvard University. The Median Multiple and other similar price-to-income multiples (housing affordability multiples) are used to compare housing affordability between markets by the Organization for Economic Cooperation and Development, the International Monetary Fund, The Economist, and other organizations”
2.5 Residual Income Method

The residual income approach focuses on the relationship between housing costs and living standards by measuring disposable income remaining after housing costs. The measure examines the adequacy of a household’s disposable income left after meeting their housing costs and the household’s capacity to maintain an acceptable standard of living with this income. Whilst the ratio method is seen as a ‘shelter-first’ method with the house and concomitant costs taking priority, this method is seen as ‘non-shelter first’ with lifestyle and non-housing expenditure taking precedence over housing expenditure (Burke and Ralston, 2003). The measure is based on the premise that households should be able to afford both housing and non-housing expenses. Ratio methods largely ignore the adequacy of after-housing income. Residual measures typically utilise a benchmark approach by measuring the minimum acceptable levels of income required to meet non-housing expenses. The focus is on ‘after-tax’ and ‘after-housing’ disposable income. Unlike ratio methods, residual approaches establish a range of benchmarks that reflect differences in household size and type. Cardew et al. (2000) found that the residual measure is viewed by many housing researchers as more realistic and appropriate. Ambrose (2005) argues that this measurement approach is more practical for households and meets the criteria of common sense and legal defensibility.

This approach requires the measurement or determination of minimum acceptable standards of living and the minimum level of disposable income to achieve this standard. The measures typically stem from policies involving social welfare, minimum income levels and household budget standards. Burke and Ralston (2003) found that the method has traditionally been used to set rent levels in socialist countries and have been influential in establishing rent levels in public housing systems. This link to welfare and the focus on minimum acceptable income levels has resulted in the measure being commonly intertwined with measures of poverty.

The Senate (2004) states that poverty can be defined in absolute or relative terms. Absolute poverty refers to individuals/households who lack the most basic living requirements such as housing, food and clothing. Relative poverty refers to individuals/households that have lower incomes and/or resources relative to other individuals/households in society. “Relative poverty is defined not in terms of a lack of sufficient resources to meet basic needs, but rather as lacking the resources required to participate in the lifestyle and consumption patterns enjoyed by others in the society” (Harding and Szukalska 2000, p. 25). The Senate (2004) found that in affluent countries, poverty is usually measured in relative rather than absolute terms.

2.6 Aggregate Economic Indicators/Indexes

Affordability indexes are used to measure trends in housing affordability on a wider macro-economic level. Berry and Hall (2001) contend that these indexes provide very important contributions to housing affordability assessment and are widely referred to in the media and by policy makers. They are based on economic and statistical indicators with the following being the most commonly used: inflation/interest rates (repayments required), incomes (capacity to pay), unemployment/employment conditions (market participation), dwelling prices and rents (payment requirements), mortgage and rent payments (savings capacity, ability to increase housing consumption), tenure (impact of market economics, hous-
ing choice), and mobility or frequency of residential relocation (aggregate housing demand and price and rent impacts).

3 GLOBAL HOME OWNERSHIP RATES

3.1 Generally

The level of home ownership rates has an important bearing on home ownership affordability. Clearly the higher the level of home ownership the more important the affordability of home ownership becomes. The Reserve Bank (2015) note that whilst home ownership rates vary significantly across countries the average ownership rates generally fall in the 60-80% range. They make the following points about global variances in home ownership rates. “There are a range of demographic, economic and institutional factors that can affect the level of home ownership, both through time and across countries. For example, strong government support for rental housing can lead to lower home ownership rates, such as in many western European countries including Germany. The tax treatment of housing, such as the deductibility of mortgage payments or the extent of capital gains tax, can also affect the relative attractiveness of home ownership and influence its prevalence. Differences in financial regulation, household structure, housing affordability, the age structure of the population, cultural values and population growth are other drivers of cross-country variation in home ownership rates” (Reserve Bank 2015, p.3).

3.2 Global Comparisons

Andrews & Sanchez (2011) note that home ownership rates have increased significantly in many OECD countries over the past few decades. Government housing policies in OECD countries generally favour the promotion of home ownership over other tenure forms. For example, higher home ownership rates have been strongly pursued by the US government over the past few decades. Andrews & Sanchez also found that home ownership rate increases were partly attributable to population ageing, rising real household income and mortgage market deregulation and innovation. The privatisation of former public housing has also increased ownership rates in countries such as the United Kingdom and Eastern European countries.

Trading Economics (2016) undertook an extensive analysis of home ownership rates for 50 different countries around the world. The following table shows the home ownership percentages and rankings of these countries.
Table 1 - Global Home Ownership Rates (Source: Trading Economics 2016)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Romania</td>
<td>90.1%</td>
</tr>
<tr>
<td>2</td>
<td>Singapore</td>
<td>90.8%</td>
</tr>
<tr>
<td>3</td>
<td>Slovakia</td>
<td>90.3%</td>
</tr>
<tr>
<td>4</td>
<td>China</td>
<td>90%</td>
</tr>
<tr>
<td>5</td>
<td>Lithuania</td>
<td>89.9%</td>
</tr>
<tr>
<td>6</td>
<td>Croatia</td>
<td>89.7%</td>
</tr>
<tr>
<td>7</td>
<td>Hungary</td>
<td>89.1%</td>
</tr>
<tr>
<td>8</td>
<td>Mauritius</td>
<td>88.9%</td>
</tr>
<tr>
<td>9</td>
<td>Nepal</td>
<td>85.26%</td>
</tr>
<tr>
<td>10</td>
<td>Norway</td>
<td>84.4%</td>
</tr>
<tr>
<td>11</td>
<td>Bulgaria</td>
<td>84.3%</td>
</tr>
<tr>
<td>12</td>
<td>Poland</td>
<td>83.5%</td>
</tr>
<tr>
<td>13</td>
<td>Russia</td>
<td>83.5%</td>
</tr>
<tr>
<td>14</td>
<td>Estonia</td>
<td>81.5%</td>
</tr>
<tr>
<td>15</td>
<td>Latvia</td>
<td>80.9%</td>
</tr>
<tr>
<td>16</td>
<td>Malta</td>
<td>80%</td>
</tr>
<tr>
<td>17</td>
<td>Czech Republic</td>
<td>78.9%</td>
</tr>
<tr>
<td>18</td>
<td>Spain</td>
<td>78.8%</td>
</tr>
<tr>
<td>19</td>
<td>Iceland</td>
<td>78%</td>
</tr>
<tr>
<td>20</td>
<td>Slovenia</td>
<td>76.7%</td>
</tr>
<tr>
<td>21</td>
<td>Mexico</td>
<td>76.4%</td>
</tr>
<tr>
<td>22</td>
<td>Portugal</td>
<td>74.9%</td>
</tr>
<tr>
<td>23</td>
<td>Greece</td>
<td>74%</td>
</tr>
<tr>
<td>24</td>
<td>Brazil</td>
<td>73.49%</td>
</tr>
<tr>
<td>25</td>
<td>Finland</td>
<td>73.2%</td>
</tr>
<tr>
<td>26</td>
<td>Italy</td>
<td>73.2%</td>
</tr>
<tr>
<td>27</td>
<td>Cyprus</td>
<td>72.9%</td>
</tr>
<tr>
<td>28</td>
<td>Luxembourg</td>
<td>72.5%</td>
</tr>
<tr>
<td>29</td>
<td>Belgium</td>
<td>72%</td>
</tr>
<tr>
<td>30</td>
<td>European Union</td>
<td>70.1%</td>
</tr>
<tr>
<td>31</td>
<td>Sweden</td>
<td>69.3%</td>
</tr>
<tr>
<td>32</td>
<td>Ireland</td>
<td>68.6%</td>
</tr>
<tr>
<td>33</td>
<td>Turkey</td>
<td>67.3%</td>
</tr>
<tr>
<td>34</td>
<td>Australia</td>
<td>67%</td>
</tr>
<tr>
<td>35</td>
<td>Netherlands</td>
<td>87%</td>
</tr>
<tr>
<td>36</td>
<td>Euro Area</td>
<td>66.7%</td>
</tr>
<tr>
<td>37</td>
<td>Canada</td>
<td>66.5%</td>
</tr>
<tr>
<td>38</td>
<td>France</td>
<td>65.1%</td>
</tr>
<tr>
<td>39</td>
<td>New Zealand</td>
<td>64.8%</td>
</tr>
<tr>
<td>40</td>
<td>United Kingdom</td>
<td>64.6%</td>
</tr>
<tr>
<td>41</td>
<td>Denmark</td>
<td>63.3%</td>
</tr>
<tr>
<td>42</td>
<td>United States</td>
<td>62.9%</td>
</tr>
<tr>
<td>43</td>
<td>Japan</td>
<td>61.9%</td>
</tr>
<tr>
<td>44</td>
<td>New Caledonia</td>
<td>60%</td>
</tr>
<tr>
<td>45</td>
<td>Austria</td>
<td>57.2%</td>
</tr>
<tr>
<td>46</td>
<td>South Korea</td>
<td>53.6%</td>
</tr>
<tr>
<td>47</td>
<td>Germany</td>
<td>52.5%</td>
</tr>
<tr>
<td>48</td>
<td>Hong Kong</td>
<td>51%</td>
</tr>
<tr>
<td>49</td>
<td>Ghana</td>
<td>47.2%</td>
</tr>
<tr>
<td>50</td>
<td>Switzerland</td>
<td>44.5%</td>
</tr>
</tbody>
</table>

Neil (2015) notes that the majority of European countries have relatively very high levels of homeownership with the notable exceptions of Germany, Switzerland and Austria. He also found that “European countries where the largest proportion of households are homeowners tend to also be countries where the majority of homeowners do not have outstanding housing debt. In contrast, countries with comparatively lower homeownership rates tend to also be countries where a greater share of homeowners have outstanding housing debt” (Neil 2015, p.1).

Bouyon (2015) notes that the lower home ownership rates in countries like Germany, Switzerland and Austria are largely due to highly developed tenant markets and specific government policy objectives. In Southern European countries like Cyprus, Portugal, Greece and Spain, the higher ownership rates can be attributed to long term dynamics where home ownership has been promoted as a means to ensure social stability. A major reason behind the high levels in Eastern European countries such as Romania, the Czech Republic, Latvia, Poland, Bulgaria and Hungary was the implementation of national policies in the 1990s aimed at promoting home ownership through subsidies (Bouyon 2015).

Florida (2013, p.1.) notes that “less developed countries have consistently higher levels of homeownership, while more advanced nations combine higher levels of economic development with substantially lower levels of homeownership. For example, Switzerland, which has the lowest rate of homeownership, is one of the the world’s richest and most advanced countries. While less-developed Eastern European nations like Slovakia and Lithuania have some of the highest homeownership levels. One reason for this may be because people in less developed nations have fewer options of where to put their money. In agrarian economies, land ownership is the basic source and measure of wealth. In more advanced capitalist economies, people have many more investment options. Many of the places with the highest rates of homeownership are in the former Communist nations of Eastern Europe”.
4 GLOBAL HOME OWNERSHIP AFFORDABILITY RATES

4.1 Generally

A range of organisations and researchers undertake regular measures of housing affordability around the world. The following provides an overview of the main measures.

4.2 Demographia International Housing Affordability Surveys

The Demographia annual international housing affordability survey is widely regarded as the most comprehensive global comparisons of housing affordability at the metropolitan area level. It covers 367 metropolitan markets in nine countries (Australia, Canada, China, Ireland, Japan, New Zealand, Singapore, the United Kingdom and the United States). A total of 87 major metropolitan markets, with more than 1,000,000 population are included, including five megacities (Tokyo-Yokohama, New York, Osaka-Kobe-Kyoto, Los Angeles, and London) (Demographia 2016).

The survey rates middle-income housing affordability using the ‘Median Income Multiple’ affordability measurement method. This measures the ratio of median house prices to median gross or disposable income in a given geographical area. It essentially measures the number of multiples of the median income required to purchase a median priced home in a particular metropolitan area. It uses the following affordability ratings:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Median Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severely Unaffordable</td>
<td>5.1 &amp; Over</td>
</tr>
<tr>
<td>Seriously Unaffordable</td>
<td>4.1 to 5.0</td>
</tr>
<tr>
<td>Moderately Unaffordable</td>
<td>3.1 to 4.0</td>
</tr>
<tr>
<td>Affordable</td>
<td>3.0 &amp; Under</td>
</tr>
</tbody>
</table>

Table 2 – Demographia Housing Affordability Rating Categories (Source: Demographia 2016, p. 2)
The following table shows the 2015 results for the 367 metropolitan markets surveyed by Demographia:

Table 3 – 2015 Demographia Housing Affordability Ratings: All Markets (Source: Demographia 2016, p. 3)

<table>
<thead>
<tr>
<th>Nation</th>
<th>Affordable (3.0 &amp; Under)</th>
<th>Moderately Unaffordable (3.1-4.0)</th>
<th>Seriously Unaffordable (4.1-5.0)</th>
<th>Severely Unaffordable (5.1 &amp; Over)</th>
<th>Total</th>
<th>Median Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>2</td>
<td>4</td>
<td>12</td>
<td>33</td>
<td>51</td>
<td>5.6</td>
</tr>
<tr>
<td>Canada</td>
<td>9</td>
<td>14</td>
<td>6</td>
<td>6</td>
<td>35</td>
<td>3.9</td>
</tr>
<tr>
<td>China (Hong Kong)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>19.0</td>
</tr>
<tr>
<td>Ireland</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>2.8</td>
</tr>
<tr>
<td>Japan</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3.9</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>5.2</td>
</tr>
<tr>
<td>Singapore</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0</td>
<td>2</td>
<td>14</td>
<td>17</td>
<td>33</td>
<td>5.1</td>
</tr>
<tr>
<td>United States</td>
<td>75</td>
<td>90</td>
<td>37</td>
<td>29</td>
<td>231</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>89</strong></td>
<td><strong>112</strong></td>
<td><strong>74</strong></td>
<td><strong>92</strong></td>
<td><strong>367</strong></td>
<td><strong>3.9</strong></td>
</tr>
</tbody>
</table>

Overall, among the 367 markets, there were 89 affordable markets, 75 in the United States, nine in Canada, three in Ireland and two in Australia. There were 112 moderately unaffordable markets, 90 in the United States, 14 in Canada, four in Australia, two in the United Kingdom and one each in Japan and Ireland. There were 74 seriously unaffordable markets and 92 severely unaffordable markets. Australia had 33 severely unaffordable markets, followed by the United States with 29 and the United Kingdom with 17. New Zealand and Canada each had six severely unaffordable markets, while China’s one market (Hong Kong) was also severely unaffordable (Demographia 2016).

Hong Kong’s Median Multiple of 19.0 was the highest ever recorded in the 12 years of the Demographia housing affordability studies. Sydney was the 2nd least affordable major market with a multiple of 12.2 (this was an increase from 9.8 in 2014 – the largest single year increase in the 12 years of the Demographia studies). Vancouver was the 3rd least affordable market with a multiple of 10.8 followed by Auckland, Melbourne and San Jose with multiples of 9.7. These were followed by San Francisco (9.4), London (8.5) and San Diego and Los Angeles (8.1).

The most affordable major markets were in the United States with a moderately unaffordable rating of 3.7 followed by Japan with a multiplier of 3.9. These were followed by Canada (4.2), Ireland (4.5), the United Kingdom (4.6) and Singapore (5.0). Whilst the most affordable they were all classified as unaffordable on the ratings scale.

4.3 The Economist Global House Price Index

The Economist (2016) produce a global house price index on a quarterly basis that tracks house price movements over the long term – it is widely used and cited in housing research. Property price movements generally have the most important impact on housing affordability so the index provides a good barometer for global affordability levels. The index also tracks these prices against average incomes to provide an indicator of affordability and whether a particular housing market may be over or under valued.
The following Figure 1 tracks residential price movements since 2000 in seven major countries. These results show that the greatest property price movements over this 16 year period have occurred in Australia (Index of 309.7 compared to base index of 100.0 in 2000), followed by Hong Kong (287.9), Britain (267.6), Canada (253.9), China (222.6), United States (176.2) and Germany (134.4). It is of note that price movements in Germany, that has a much lower proportion of home owners than the other countries, has had a much lower level of price increases. British and the United States were on a similar trajectory between 2000-2006 rising by about 80% but the roof subsequently fell on the United States housing market due to the sub-prime housing mortgage crisis and other economic problems. The United States market has begun to rise back up from 2012.

**Figure 1** – Residential Property Price Movements: 2000-2016 (Source: The Economist 2016, April, p. 1)

All countries have generally seen a marked escalation in prices since 2010. The Economist (2016) has found that in some cities/countries the past few years has seen unprecedented increases. Their latest statistics show that prices have risen by an average of 5.1% over the past year (after adjusting for inflation) in 20 of the 26 countries that they develop price indices for. However, in what they call ‘pre-eminent’ cities, the average rise has been 8.3% over the past year. They make the following comment. “Globalisation has created a handful of metropolises that attract people, capital and ideas from all over the world, almost irrespective of how their national economy is doing. House prices in such places, unsurprisingly, outpace the national average” (The Economist, 2016, p.1). For example, the value of houses in San Francisco, Vancouver, Sydney and Shanghai has increased by 12% per annum over the past three years which is twice their respective national averages.

The following figure shows residential price movements over the past three years for 8 countries and compares that to the corresponding averages for the main cities in each country. It also assesses the value/affordability of these prices in relation to income and rents.
Figure 2 shows a clear distinction between residential property price increases in major capital cities compared to the national averages. Whilst these cities would be expected to be higher the extent of the difference is quite remarkable with Sydney, London and San Francisco having the greatest increases. To determine whether homes are fairly valued, Figure 2 also looks at the relationship between prices and disposable income (an indicator of affordability) and between prices and rents (a substitute for buying a home). If rising prices move these ratios above their long-run averages, then either incomes or rents are likely to rise, or house prices to fall. The Economist (2016, p.1) argue that the above results indicate that housing is approximately 45% over valued in Australia, Britain and Canada (largely due to the large increases in prices in their respective capital cities). For example they note that “between 2002 and 2012 the typical London home sold for seven times the city’s average annual salary - that figure has since risen to 12 times”.

5 GLOBAL AFFORDABILITY ISSUES

5.1 Government Priorities

Demographia (2016) contend that virtually all governments place household economic issues as a top priority particularly in relation to improving standards of living and reducing or even eradicating poverty. They cite the recent ‘Group of 20’ (G20) summit in 2014 in Brisbane, Australia whereby the 20 countries (including China, Russia, France, Japan, Canada, Australia and the United States) all signed a communique declaring ‘better living standards’ as a highest priority and a commitment to poverty education.
Eroding housing affordability levels have seen housing costs generally rising much faster than income. Demographia (2016, p. 26) make the following comment. “Discretionary income trends are even more concerning. Housing costs, which represent the largest household expenditure category, have been rising much faster than incomes. The resulting stagnation or even decline in household discretionary incomes is at least as much a threat to prosperity and job creation as the limited gross income gains”. The residual incomes left after taxation and housing costs are dwindling and leaving less and less to contribute to wider economic activity and meeting other household needs.

5.2 Addressing Global Affordability Issues

Demographia pinpoint land use restrictions as a key cause of the significant decline in affordability levels in many countries in recent years. “Historically, the Median Multiple has been remarkably similar in Australia, Canada, Ireland, New Zealand, the United Kingdom and the United States, with median house prices from 2.0 to 3.0 times median household incomes. However, in recent decades, house prices have been decoupled from this relationship in a number of markets, such as Vancouver, Sydney, San Francisco, London, Auckland and others. Without exception, these markets have severe land use restrictions (typically “urban containment” policies that severely ration land for development on the urban periphery) that have been associated with higher land prices and in consequence higher house prices (as basic economics would indicate, other things being equal). Further, periodic reviews of housing supply, put in place to maintain housing affordability in these metropolitan areas have generally not succeeded” (Demographia 2016, p.1)

Day (2016, p.1) describes the problems that this is creating in these unaffordable markets. “The economic consequences of these changes have been devastating. The capital structure of these countries’ economies have been distorted to the tune of hundreds of billions of dollars and for those on middle and low incomes the prospect of ever becoming homeowners has now all but vanished. Housing starts are below what they should be and so have all the jobs associated with them - civil construction, house construction, transport, appliances, soft furnishings, you name it. Not to mention billions of dollars in lost taxes and other housing-related revenue to the nation state. The distortion in the housing market, this misallocation of resources resulting from the supply-demand imbalance is enormous by any measure and affects every other area of a country’s economy. New home owners pay a much higher percentage of their income on house payments than they should. Similarly, renters are paying increased rental costs reflective of the higher capital and financing costs in turn paid by landlords”. Day also highlights that whilst focus has typically been placed by governments on demand drivers like capital gains tax treatment, negative gearing, interest rates, readily accessible finance, first home buyers’ grants and high immigration rates the real problem lies in the lack of land supply and regulations that restrict the release of new land supplies and re-zoning for appropriate residential development.

Angel (2009, p.1) concurs: “For cities to expand outward at their current pace – to accommodate their growing populations or the increased demand for space resulting from higher incomes – the supply of land must not be artificially constrained. The more stringent the restrictions, the less is the housing market able to respond to increased demand, and the more likely house prices are to increase. And when residential land is very difficult to come by, housing becomes unaffordable”. Brash (2008, p.1) adds further weight to the land argument: “the affordability of housing is overwhelmingly a function of just one thing, the extent to which governments place artificial restrictions on the supply of residential land. Australia is perhaps the least densely populated major country in the world, but state governments there have contrived to drive
land prices in major urban areas to very high levels, with the result that in that country housing in major state capitals has become severely unaffordable”.

The McKinsey Global Institute (2014) highlight the extent of the problem and the significant challenges faced. They estimate that approximately $16 trillion worth of land investment and construction work would be required to replace substandard housing and building new housing to meet expected needs by the year 2025 (an approximately 10 year time frame). They note that approximately 15-20% of the funding for this would be required from the public sector. In a major global research study, the Institute identified four key ways to reduce the cost of delivering affordable housing by 20-50%.

- Reduce the cost of land by releasing land in the right locations and reducing restrictive land release policies. This was considered to be the most important strategy which is consistent with the recommendations provided above by other housing researchers.
- Reduce construction costs through value engineering and industrial approaches
- Improving housing operational and maintenance efficiencies
- Reducing financing costs and provision of innovative financing solutions for both purchasers and developers.

They emphasise that new approaches are required and actually open up tremendous opportunities for private sector investment and the finance sector. They predict that the largest markets for new construction for low-income affordable housing by 2025 would be in China, Russia, India, Brazil and Nigeria. With approximately $16 trillion worth of construction/development work required over the next ten years (as outlined above) the McKinsey Global Institute (2014) predict that this would require mortgage issuance from the finance sector of $300-400 billion per year equating to approximately 7% of global new mortgage origination volume by 2025.

6 CONCLUSION

Affordable and appropriate housing is a basic human need that is fundamental to the health and well-being of individuals and the proper functioning of any society, city or country. This is a global problem and a challenge for all countries around the world – both for developed and developing countries. In many developed countries, affordability has become a major issue for many households who would be considered affluent on a global scale. For example, residents of major global cities such as London, New York, Sydney and Vancouver may enjoy relatively high incomes but face exorbitant costs to enter and stay in the home ownership market due to spiralling residential property prices. This may result in purchasers’ housing costs accounting for over 50% of their incomes or not being able to enter the home ownership market at all. The problem is then clearly compounded for low/middle income-earners, the under-privileged, the homeless and other disadvantaged groups in these areas. In developing countries the focus tends to be more on addressing the provision of affordable housing/home ownership for low-income earners and the disadvantaged.

Irrespective, home ownership affordability is a global concern for all governments around the world and will continue to present challenges and opportunities that can be met through the global sharing of best practices and innovative solutions.
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Contract and Claim Management (CCM) in Product vs Project Business

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ABSTRACT

Purpose of this paper

Studies carried out in different business sectors, like “petrol, oil & gas” and “metal technologies”, have evidenced the need of Contract & Claim Management (CCM) as Total Cost Management method to create value, especially in situations characterized by heavy competition/complexity and economic crisis conditions. Considering that CCM methods have been successfully introduced in companies operating in project business, the purpose of this paper is to show the opportunity of CCM systematic application in companies operating in product business, pointing out analogies and differences between the two kinds of contexts.

Design/methodology/approach

The CCM perspectives in product vs project business are analysed evidencing the following differences:

- Methodology approach (product lifecycle vs project duration);
- Impact on organizational structure (Contract and Claim Manager supporting product manager vs project manager);
- Contractual focus (product delivery/functionality vs project completion and relevant target achievement);
- Strength & weakness points in the contractual matters (focus on product vs project responsibility);
- Specific success factors and claim approaches driving the contractual negotiation processes;

Case study examples are illustrated to evidence differences between CCM in product vs project business, but raising that CCM can be analogously a value added in both kinds of contexts.

Findings and value and practical implications

As consequence of the analysis supported by the case studies, CCM application can be a driver to create value not only in project business, but also in product business, provided to introduce a Contract and
Claim Manager figure tailored on the different characteristics and processes, operating with a product lifecycle involvement rather than with a project duration perspective.

Originality/value of paper

Support the programmatic application of CCM within the company Organizations operating in product business, which are currently mainly driven by the product delivery/functionality achievement, with limited dynamism of contractual matters as a driver to create value.

Conclusions:

CCM as TCM Method application is a significant opportunity to create value in product business, introducing a proper Contract and Claim Manager figure following contractual matters during all the phases of the product lifecycle.

Keywords: CCM, Product Business, Project Business

1 INTRODUCTION

The Contract & Claim Management (CCM) as Total Cost Management (TCM) Method has become an important support for the companies in the governance and the control of the project executions for the implementation of industrial plants, providing Value to the projects through the proper implementation of a Contract and Claim Manager Figure and the application of the CCM Methodology, contributing in the achievement of various targets:

i. reduction of non-conformance costs;
ii. EBIT stabilization or increase compared to original forecast;
iii. reduction of risks;
iv. increase of opportunities;
v. improvement of quality and efficiency of the Management;
vi. support / increase of contractual strength towards external parties (i.e. Customers and Vendors);
vii. gain lesson learnt for future.

Recent studies have identified that the reasons of the CCM affirmation in the project business are the globalization, the reduction of the economic power caused by the global crisis, the tendency to saturation of the market, the increase of complexity of markets.

But the same factors have determined not only the success of CCM in project business, such as the market of industrial plant implementation and metal technologies, but have triggered the introduction of similar principles and methodologies also in other kind of contexts, like the business of specialized components and products for petrol, oil & gas and similar sectors.
Hereinafter in this paper (chapter 2), the CCM perspectives in product vs project business will be analysed pointing out the relevant peculiarities and differences.

Subsequently, case studies will illustrate examples of CCM application in product business and project business, pointing out that CCM can be analogously a value added in both kinds of contexts (chapter 3).

Further, the paper will compare the programmatic application of CCM Methodology and Figure within the Organizations working in product business vs the organizations working in project business (chapter 4).

Finally (chapter 5), the paper will sustain CCM as TCM Method application product business as an opportunity to create value, introducing a proper Contract and Claim Manager Figure tailored on the “product” perspective.

2 CCM PERSPECTIVES IN PRODUCT VS PROJECT BUSINESS

The different contexts of the above called “project business” and “product business” can be represented as follows.

Suppose a Supplier (A) of technological and specialized components, whose Customer is a Contractor (B) implementing a turn-key plant for a multinational oil & gas End User.

A is a Company operating in a product business, whose output is characterized by protected know-how.

B is a Company typically operating in a project business, focused on managerial competences to follow activities and deliveries of different Suppliers, in order to carry out the requirements and specifications committed by the end user of the plant.

Companies A and B would have different perspectives and peculiarities in the CCM application, as analysed herewith, taking into considerations the various drivers and factors.

2.1 CCM Methodology Approach

The typical business of a company operating by project is based on the project execution's duration, from the awarding of the order until the completion of the plant in all its phases: kick off, detailed analysis for specification implementation, design, construction, delivery, start-up, commissioning, acceptance, warranty period.

The CCM Methodology is usually applied to all the phases of the project.

From the kick off to the design phases, the Parties start to put in place the contractual stipulations (i.e. issuance of bank guarantees and letters of credits, definition of operative time schedule, activation of communication protocols, etc.) and agree any specific aspects and points that are eventually not completely defined in the Contract (i.e. interface areas of the plant, any machines whose detailed require-
ments were left to be defined in a later stage subsequent to the order awarding, etc.).

During the construction and delivery, the site and transportation issues shall be managed and risks shall be controlled and reduced through CCM application.

The start-up, commissioning and acceptance phases are critical from a CCM perspective because the plant shall be started and tested in accordance to the contractual stipulations and acceptance criteria. These are also the phases when any claims eventually raised by the Parties during the project come to a mutually agreed resolution through a punch list settlement.

Finally, during the warranty period, it is necessary to manage the contractual relationship in case of defects, in order to set if the issue is attributable to Contractor responsibility and in order to define it falls into warranty period and terms.

A company operating by product would face similar aspects, but within the product lifecycle perspective instead than project duration perspective.

Especially in products designed with a highly specific know-how to be protected, the CCM Methodology shall support the management during the relationships with the Customer in order to define which information can be disclosed and which not.

The main focus during the manufacturing job is on the delivery on the products within the contractual terms. The CCM aspects relevant to the shipment, start-up and commissioning phases are similar to the project business, following shipment and installation phase and ensuring the achievement of parameters for acceptance after commissioning.

The warranty period is usually related to the management of product issues, taking lesson learnt for similar products supplied for other Customers, in order to implement preventive actions avoiding the repetition of similar issues.

2.2 Impact on organizational structure

Project business is typically managed by a project team, coordinated by a Project Manager and preferably assisted by a Contract and Claim Manager supporting the project development from a contractual point of view.

The companies having adopted a full CCM approach usually have a Contract and Claim Manager Figure who leads the execution of Projects and the relationship with Customers from the contractual perspective, as well as induce all the Project Organization to operate continuously with CCM attitude. These kind of tasks are under the responsibility of the Project Manager where the CCM Figure is not implemented.

The companies operating in product business have a product lifecycle perspective and a structure orga-
nized by functions, instead than by dedicated project teams. The various business functions (i.e. engineering, production, quality, logistics, etc.) usually communicate each other through the support of a coordination role who also manages the relationship with the Customer during critical phases like manufacturing, delivery, commissioning and acceptance. Then an After Sales department usually takes in charge the Customer’s requests during warranty period and lifecycle of the product.

The CCM Figure is not consistently implemented in companies operating in product business, but considering the CCM topics that could arise during the product lifecycle, it could be helpful to support the coordination figures and After Sales department, in order to assist with responsibilities and activities definition.

2.3 Contractual focus

A company operating in project business is focused on the project completion with the target to satisfy all the requirements and the parameters.

Many drivers shall be controlled to achieve the satisfaction of the Customer: coordinate the activities and the deliveries of various Suppliers, follow up internal production and delivery, set up site management and structure, organize supervision during start up and commissioning phase, follow the test and the acceptance of the plant.

The product business is focused more specifically on the achievement of the delivery dates and product functionality only. On the other hands, the technical peculiarities could be various, based on the range of products.

2.4 Strength & weakness points in the contractual matters and negotiations

The difference between product and project perspective implies also differences in the strength & weakness points in CCM matters.

The project business is carried out by Contractors having a responsibility in the project result and being characterized by organization with high managerial competences.

These competences, often joint to solid brands, are strength factors in the negotiations and contractual matters.

Vice versa, weakness points can be identified in the very high liabilities on the whole plant value and performance, facing multinational companies as Clients, while the liabilities towards Suppliers are limited to each relevant portions of supply. For these reasons, the contractual power of companies operating by project, are limited towards vendors and, on the other hand, the contractual exposure towards Customers is a huge and critical risk factor.

Further, the know-how of the plant's components usually belongs, at least for external furniture, to the Suppliers, with the consequence that the Contractor depends by Suppliers' performances and support
regarding technical results.

From a specular point of view, the companies operating in product business are focused on the supply of the product, often characterized by protected know-how.

The organization of these companies is not used to adopt CCM Methods in the management of the relationship with the Customer, because they are typically small-medium companies operating with smooth procedures oriented to the result delivery only. Due to their structures, they are less oriented to negotiations and claim discussions with the Customer.

On the other hand, the strength points of these companies from a CCM perspective are the limited liability and the technological know-how, which is an essential need for their Customers. In this work, the cost of disruption is considered a fuzzy variable, and will depend on the nature of operations of the current building occupants. In order to apply the principles of fuzzy logic, it will be necessary to define the tolerance values specified by Ayyub (2006) in evaluating the respective cost of disruption.

2.5 Contractual differences and contract & claim approaches

The essence on both “project business” and “product business” contracts is the delivery time and the performance of the supply (the plant in project business, the specific component in the product business).

The performance of a plant is measured on a wider range of parameters compared to the performance of a specific product, because usually a plant is composed by many products, machines and components furnished by different Suppliers.

A major difference is regarding the liability:

i. Contracts in project business usually state a liability at least equivalent to the total value of the plant, with responsibility of site conditions, health and safety requirements and (Peter Davison and Mullen, 2009) site facilities and equipment [...] (which) include scaffolding and access equipment, general craneage and site concrete batching plants as well as site offices, messing and welfare and safety facilities. Liquidated damages are applicable not only for delay of supplies delivery but also for delay of the start-up of the plants. Acceptance parameters are related to various machines and components of the plants.

ii. Contracts in product business usually state a liability not higher than the total value of the components supplied. Liquidated damages are applicable only for delivery delay, because the responsibility to start up the plant stays with the Customers (which are mainly plant constructors). Acceptance parameters are related to the specifically supplied equipment only.

It is possible to find differences also in the contractual “mood” between the companies operating by project vs the companies operating by product.

In the project oriented companies, the aim is to focus on a mix of contractual aspects to be negotiated to find a resolution to a “plus and minus” list, leading to a mutual satisfaction to the Parties.
The approach is both defensive and offensive, with possible variations due to the multiple variables that could determine the progress of the project.

In the product oriented companies, the focus is the internal control to deliver the supply according to the specifications and the schedule contractually foreseen, with a defensive claim management approach. The reason is that the CCM application is more contextualized to specific scope compared to the project business.

3 CASE STUDIES

We herewith report two case study examples of CCM application: one in a project business context and one in a product business context.

3.1 Case study of CCM application in a project business context

A Contractor operating in metallurgical services projects, entered into a Contract for the implementation of an industrial plant, including supply of equipment (on free on board basis) and advisory services for erection and commissioning.

Liquidated damages for performances were contractually applicable for underachievement of performances during the acceptance tests and liquidated damages for delivery delay were applicable in case of delay in the start-up date of the plant, attributable to the Contractor only, compared to contractual delivery schedule (calculated as total Contract Value x 0.5% x number of weeks of delay, up to 10% of Contract Value).

Warranty period of the Contract equipment was twelve months from the achievement all the performance tests of the plant and relevant acceptance certificate signature between the Parties.

The start-up was achieved with 7 weeks of delay compared to the contractual schedule and the Customer claimed liquidated damages to the Contractor calculated on the whole delay period.

The Contractor, based on a CCM perspective application, having properly kept track of all the records, delivery notes and minutes of meeting during the execution of the project, was able to argue that:

i. The last equipment were manufactured and made ready for delivery with 4 weeks of delay, due to production issues faced by a Contractor’s Supplier;

ii. The civil works performed by the Customer on site were completed with 2 weeks of delay, with the consequence that 2 of the 4 weeks of delay due to manufacturing issues were not a cause of the start-up postponement because of concurrent delay;

iii. The transportation of the last equipment at site required 4 weeks instead than 2 weeks, that means 2 weeks of delay compared to the foreseen schedule, caused by the shipping forwarder, appointed by the Customer (because the contractual delivery terms were “free on board”), due to late vessel nomination;

iv. When all the equipment were finally available at site, 1 further week of delay occurred due to an unforeseen force majeure event (a typhoon), not claimable by the Parties each other;
Considering the above evidenced argumentation, the Contractor concluded that, with reference to the total 7 weeks of delay:

i. Only 2 weeks (pertaining to manufacturing issues) were attributable to Contractor only and consequently claimable by the Customer;

ii. The other 2 weeks of delay for manufacturing issues were not claimable due to the concurrent delay of the Customer in completing the civil works;

iii. 2 weeks of delay were responsibility of the Customer because of issues faced by the shipping forwarder;

iv. 1 week of delay was not claimable by the Parties because relevant to a force majeure event.

According to these argumentations, the Contractor was able to amicably convince the Customer at project management level to be claimed only of 2 weeks of delay instead than 7 weeks (calculated on the total project contract value).

Further the Contractor claimed to its Suppliers the 4 weeks of delay caused by manufacturing issues (calculated on the product value), recovering part of the costs incurred due to the Customer's claim.

| Activities       | Resp.          | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 | W15 | W16 | W17 | W18 |
|------------------|----------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|
| Manufacturing    | Contractor     |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |
| Civil works      | Customer       |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |
| Shipment         | Customer       |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |
| Force Majeure    | None           |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |
| Start up         | Customer & Contractor |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |

According to these arguments, the Contractor was able to amicably convince the Customer at project management level to be claimed only of 2 weeks of delay instead than 7 weeks (calculated on the total project contract value).

Further the Contractor claimed to its Suppliers the 4 weeks of delay caused by manufacturing issues (calculated on the product value), recovering part of the costs incurred due to the Customer's claim.

### 3.2 Case study of CCM application in a product business context

A Supplier selling products and components for oil & gas lines entered into a Contract for the supply of equipment (on free on board basis).

Liquidated damages for performances were contractually applicable for underachievement of performances during the acceptance tests and liquidated damages for delivery delay were applicable in case of delay.
compared to the delivery date agreed in the Contract (calculated as total product price x 1% x number of weeks of delay, up to 5% of total product price).

Warranty period of the Contract equipment was twelve months from the start-up or eighteen months from delivery, whichever occurred earlier.

All the equipment were delivered in time and the start-up was delayed for reasons attributable to the Customer only, who was in charge of the erection and commissioning of the plant for the end user.

After the Start-up, two Supplier's products were affected by some functioning issues and the Customer requested the Supplier's intervention under warranty terms.

The Supplier, based on a CCM application, having properly kept track of all the records, delivery notes job documentation, was able to argue that:

i. For one product the defect liability period stated by warranty terms was terminated at the time of the occurrence, because, notwithstanding less than one year had occurred from the start-up, due to the Contractor's delay, more than eighteen months had already occurred from delivery of equipment, according to packing lists and delivery notes. In particular, twenty-one months occurred;

ii. For the other product, the site supervision recording evidenced that the Customer performed an intervention on a component without the presence of Supplier's personnel, despite Supplier's written request, and further wrongly following the instruction manuals duly provided by the Supplier.

According to the above argumentations, the Supplier was available to convince the Customer to perform repair and supervision at charge, even recognizing a discount in spirit of cooperation to keep the good relationship with the Customer in the long period.

In parallel, the Supplier was able to successfully claim to its vendor the defect to the component that caused the malfunctioning to the product. In fact, warranty terms between Supplier and its vendor were twenty-four months from delivery.

Consequently, the Supplier's vendor replaced the component free of charge.

4 CCM APPLICATION COMPARED IN PRODUCT VS PROJECT BUSINESS

The CCM Methodology and Figure application within the Organizations working in product business vs the Organizations working in project business can be compared as herewith schematized, considering similarities and differences in managing the Contract Relevant Events (CRE).

Amongst the similarities, the different specific aspects between CCM and project business and product business are highlighted in bold.
5 CONSIDERATIONS AND CONCLUSIONS

As described in this paper, the programmatic application CCM Methodology and Figure can be carried out not only in the organizations of companies operating in project business, but also in companies operating in product business, because CCM is an instrument supporting the creation of value fitting both kinds of context, provided that the matter is tailored on the different specific peculiarities.

In particular, if the project business has developed a CCM culture and consistency through these years, an implementation of adapted CCM principles could be beneficial also to companies operating in product business, which are usually mainly driven by the product delivery/functionality achievement, with limited dynamism and attitude towards contractual matters as a driver to create Value.

CCM as TCM Method application is a significant opportunity to create value in product business, introducing a proper Contract and Claim Manager Figure following contractual matters during all the phases of the product lifecycle.

6 REFERENCES

Classification and characterization of losses involved in public building work: a case study in the city of Salgueiro / PE, Brazil

Allison Danrley, Maria do Socorro Bezerra Sá, Ires Maria dos Santos, Brenda Maria da Silva Martins, Eduardo da Cruz Teixeira, Camila Macêdo Medeiros

ABSTRACT
The Cost Engineering has a fundamental role in the planning and control of the resources involved in production processes in civil construction, which is characterized by heterogeneity of the stages and the agents involved. This heterogeneity is also combined with the complexity of the interrelationship between stages of the process, favoring the occurrence of failures reflecting on additional consumption of resources in relation to the planned projects are the losses that happen in construction. It is estimated consumption of 1 ton of different materials for the production of 1 m² of finished construction, therefore, the loss of materials represent an increase in the total cost of construction, being a waste of resources. This fact also affects the environment, as much of the building materials has its raw material from the resources available in nature, as well as approximately 2/3 of the hours worked by laborers involved in the process are not productive hours, consumed by activities flow. This work approach with the characterization and classification of losses incurred in a public building work, administered by the city of Salgueiro / PE, Brazil, taking into account the flow of activities involved in that process by offering data able to classify what type of loss involved, quantify their financial representative and providing parameters to optimize the process that the loss occurred, making a bridge of Cost Engineering and Public Works Management. The survey of the losses occurring in the services related to the reinforced concrete structure, which represent approximately 30% of the project budget in question. They were taken as parameters the unit prices of compositions of the contracted services of structural reinforced concrete, wooden formwork and steel armor and carried out survey of resources consumed in the implementation process: material, labor, transport involved, displacements and consumption tools. It was observed in that survey losses, the flow of activities were not covered in hand use rates of work of those cases, causing a cost not compatible with what was executing, in addition to vertical transportation services not provided for in original budget, the loss of materials had significant impacts, however, caused by implementing management failures.

Keywords:
1.0 INTRODUCTION

The construction industry, when compared to other industries, is characterized by the heterogeneity of the stages and the agents involved in the construction process. This heterogeneity is also combined with the complexity of the interrelationship between the steps of this process, favoring the occurrence of failures reflecting in additional consumption of the relative resources provided for projects (PALIARI, 1999).

Studies performed in Brazil and abroad prove the fact off the need for planning, pointing out that the main causes of low productivity in the constructor sector are directly linked to deficiencies in planning and control, also generating a high loss rate (ISATTO et al., 2000).

The high incidence of loss in construction is also related to the quality of the indices considered in the measurement of quality. Soibelman (1999) determines that the waste is considered as a consequence of a low quality process, resulting in final products of poor quality.

The concept of losses in construction is commonly associated with waste materials, however, its design goes beyond this concept and should be understood as any inefficiency that is reflected in the use of the equipment, materials, labor and capital in amounts greater than those necessary for the production of the building. Such losses are the result of a low quality process, that brings as a result not only an increase of costs and a final product with inferior quality (FORMOSO et al., 1996).

The labor losses refers to the time spent by workers in activities that do not incorporate value to the final product and can easily be reduced or eliminated without causing any damage, such as waiting time, rework, transportation, among others. KOSKELA and SCARDOELLI (apud, VARGAS et al, 1997) show alarming data: The tie of working loss of workers can reach up to 50% of the total time. The Lean Construction shows itself as an effective way to carry out the management in construction, and which may reduce the activities that do not add value, increase transparency and flexibility of the whole process.

Given this, this paper has as main aim the study of manpower losses in the service of reinforced concrete structure in a public construction of the city Salgueiro, Pernambuco, located in the central wilderness of the state Pernambuco in Northeastern, Brazil. Differently from the national scenario, the city goes through a time of “boom” in construction, with great federal, state and municipal public construction, as well as private investment, reflecting in a strong economic growth. Large works as Transnordestina, Transposition of Sao Francisco River and the logistics platform, linking Salgueiro to the Port of Suape, increase employment opportunities in the city, bringing local development and, thus, there is an increase of the amount of people from other cities and states interested in working there. With this, comes the need to build more houses and general infrastructure to accommodate the housing growth. Local builders and small builders saw in it the opportunity for investment in civil construction, significantly increasing the number of construction in the city.
2.0 LITERATURE REVIEW

According to Formoso, 1996 “Losses [...] shall be understood as any inefficiency that is reflected in the use of equipment, materials, labor and money in quantities exceeding those necessary for the production of the building.” Therefore, losses can be made at all stages of a construction. Thus, there are two classifications for activities related to the loss in construction, they are:

- Conversion Activities: involve the processing of materials into finished products (FORMOSO et al, 1996), that is, for example, the process of building a wall and having to redo it consists in material and time losses, in referring to the material process in products.

- Flow Activities: They relate to the tasks of inspection, moving and waiting for the materials (FORMOSO et al, 1996), some of the examples that fit this type of activity would be the waiting for a truck loaded with cement, since that was not established the right time to deliver the construction. To reduce the losses in building constructions it is necessary to know its nature and identify its main causes. With this objective, the losses are categorized by FORMOSO et. al. (1996), according with its nature. The criteria of categorization used by FORMOSO et. al. (1996) were adapted from studies performed by Shingo (1981) and Skoyles (1987) to the Brazilian civil construction:

- Losses by overproduction: refers to the losses that occur because of production in higher amounts than necessary, for example: production of mortar in a higher amount than the necessary for one day of work.

- Losses for substitution: They occur after the utilization of a valuable material or performance feature higher than the specified ones, as: using mortar with higher resistance trace than specified.

- Losses by waiting: Related to the synchronization and flux leveling of materials and workers activity. They can involve both losses in labor and equipment, for example stoppages caused by lack of availability of equipment or materials.

- Loss for transportation: the losses for transportation are associated to excessive or improper handling of materials and components because of bad planning of activities or because of a inefficient layout, as, for example, excessive time spent in transportation because of great distances between stock and winch, breaking materials due to its double handling or the use of improper transport equipment.

- Losses in processing: they are originated in it own nature of activities of the process or in the inadequate execution of them. They occur because of the lack of standard procedures and inefficiency in the methods of working, the lack of training for the labor or deficiency of the detailing and constructiveness of the projects. For example of this type of loss: cracking plastered walls to enable the execution of the facilities; breaking guide blocks due to lack of half-blocks.

- Losses in stock: they are associated to the existence of excessive stock, due to the inadequate program for the deliver of materials or mistakes in the budgeting, may give rise to situations of lack of suitable sites for the deposition of the same. Also result from the lack of care in the materials
storage. Can result in both material and money losses, for example: Também decorrem da falta de cuidados no armazenamento dos materiais. Podem resultar tanto em perdas de materiais quanto de capital, como por exemplo: Financial cost of inventories, deterioration of the cement due to storage in contact with the ground and or in too tall piles.

- **Losses in motion**: result of performing unnecessary movements by workers during the execution of their activities and can be generated by remote work areas and difficult to access, lack of site layout study and workstation, lack of appropriate equipment, etc. Examples of this type of loss: excessive handling time between workstations due to lack of programming a proper sequence of activities; worker overexertion due to unfavorable ergonomic conditions.

- **Losses for the preparation of defective products**: occurs when manufactured products that do not meet the specified quality requirements. Usually originate from the lack of integration between the design and execution of the shortcomings of planning and control of the production process; the use of defective materials and lack of training of the workers. Result in reworking or reduced performance of the final product, for example, failures in the waterproofing and paints, tiles detachment.

- **Others**: there are types of losses of different natures from previous ones, such as theft, vandalism, accidents, etc.

### 2.1 Manpower Losses

According to Souza, 2000, the manpower is the most precious resource participant in the execution of civil construction, not only because it represents a high percentage of the total cost but, mainly due to dealing with human beings who have a number of needs that should be met. The labor losses refers to the time spent by workers in activities that do not incorporate value to the end product and can easily be reduced or eliminated without causing any damage. Include: waiting time, rework, transportation, etc.

In a survey conducted by Grohman, among the key measures identified by the business community to avoid the labor of waste, the most frequent were: inspection of employees (88.24%), the personnel training (70.60%) and technical improvement (64.71%). Inspection of the staff refers to the observation of the work of master or another professional in order to avoid “laziness”, as words of one respondent. The first place obtained by this item shows negative aspects such as: the lack of confidence in the workers and the use of corrective measures rather than preventive.

However, the company transfers to the employee responsibility for labor waste if exempting of him, because a good part of the losses in the services may be caused by lack of management by the construction company, for example, the expected losses, where workers are still awaiting the arrival of a certain material, without having to sync between the flows of materials and activities of workers.

### 2.2 Tool of management

The international financial crisis has affected the Brazilian economy. In 2015 Brazil faced a difficult economic crisis: inflation and high interest rates, increased light, gas, Ethanol, diesel, cooking gas, transport and food, in addition to the high rising dollar; and in the construction sector was no different, work po-
positions were closed, the share of GDP fell in 2015, the housing market has cooled and some construction companies went bankrupt. The specialist in macroeconomics, Paulo Junior, published an article in the magazine, claiming that the year 2016 will be even worse, unemployment will reach 10%, with construction leading. At times like this, companies need operational, logistical, technological and innovative adjustments, competition in the market will make the civil construction companies to offer their products or processes in a more competitive price with integrated technical quality; productivity and quality are two pillars needed to be safe in an unstable market, pessimistic and cold; which was installed in the Brazilian economy. The management of the construction is shown as an ally to the reduction of losses in construction, and it was from the need to supply the low efficiency and achieve better production management levels, the Finnish Koskela in 1992, conducted studies that resulted in the model appearance for production management in construction called Lean construction. This management model is derived from the lean production (Lean Production) (LORENZON; MARTINS, 2006). Lean Construction introduces the concept of construction management, aimed at streamlining and optimizing processes in construction. This is the result of a precursor project in construction, being able to be used effectively in any type of construction project. Moreover, its application influences the development of teamwork and partnership, making the relationship of trust to be strengthened in the workplace, and so avoid that employees seek to optimize performance individually and emphasize the overall optimization construction (HOWELL, 1999; Lima; UGULINO, 2009).

The Lean Construction seeks to coordinate organizations from a structured planning, which has a clear and objective set for the delivery process, the aim is to maximize the performance for the customer, it is performed a simultaneous process of product and process, using production control throughout the project life cycle, not only in isolated periods. Thus there is the reduction of costs and delivery time, causing waste are prevented and / or eliminated (BALLARD; HOWELL, 1997; HOWELL, 1999).

2.3 UPC (Unit Price Composition)

This tool is part of the budget of a construction, especially for public constructions that are governed by current legislation and guidelines of regulatory agencies, therefore, lies in the Budget Worksheet to be drawn up in accordance with the specifications of services and materials, if it exists, and the projects that make up the enterprise. The project is to provide quantitative services. The itemization of this spreadsheet will allow the selection of UPCs that will make up the budget. Defined quantitative and unit prices of all services, operationalize the spreadsheet and gives the final value of the enterprise, whether for sale or for cost. The UPC deals specifically with quantification of inputs that are part of a particular service of the work accompanied by the corresponding unit price. It is the value corresponding to each service unit. Service units are those contained in the budget breakdown.

The UPC can have the following components:

- Inputs (materials, labor, equipment, third-party services);
- Quantities (indices or coefficients) of application materials, production or labor application, application equipment and application of third-party services;
- Unit prices of materials, labor, equipment and third party services;
- Rates of Social Laws (which relates only to the labor); and
- BDI (when the UPC is selling, otherwise there is no BDI).
3.0 METHODOLOGICAL PROCEDURES

This paper is the result of a research project developed at the Federal Institute of Backwoods Pernambuco, Brazil - Campus Salgueiro in meeting the demand of studies by the Municipality of Salgueiro / PE on classification and characterization of manpower losses in engineering services.

It was developed in a public work, contracted by the city, that it is the construction of a Basic Health Unit, budgeted at R$ 420,082.81, taken as a case study. To meet the objectives of the work, which deals with the characterization and classification of labor losses, research analysis made only in the service of reinforced concrete structure, budgeted at R$ 99,912.20, representing 23.78% of the total construction as shown in Table 01.

<table>
<thead>
<tr>
<th>Services description</th>
<th>Total (R$)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOBILIZATION – CONSTRUCTION SITE - DEMOLITION</td>
<td>R$ 10,128.05</td>
<td>2.41</td>
</tr>
<tr>
<td>GROUND MOVEMENT</td>
<td>R$ 3,865.11</td>
<td>0.82</td>
</tr>
<tr>
<td>CONCRETE REINFORCING STRUCTURE</td>
<td>R$ 99,912.20</td>
<td>23.78</td>
</tr>
<tr>
<td>MASONRY - SEALING</td>
<td>R$ 38,003.90</td>
<td>9.05</td>
</tr>
<tr>
<td>COATINGS</td>
<td>R$ 121,187.50</td>
<td>28.85</td>
</tr>
<tr>
<td>FRAMES</td>
<td>R$ 51,371.31</td>
<td>12.23</td>
</tr>
<tr>
<td>ELECTRICAL INSTALATIONS</td>
<td>R$ 50,272.34</td>
<td>11.97</td>
</tr>
<tr>
<td>HIDRAULIC INSTALATIONS</td>
<td>R$ 37,943.64</td>
<td>9.03</td>
</tr>
<tr>
<td>VISUAL COMMUNICATION</td>
<td>R$ 6,114.75</td>
<td>1.46</td>
</tr>
<tr>
<td>OTHERS AND CONSTRUCTION CLEANING</td>
<td>R$ 1,284.11</td>
<td>0.31</td>
</tr>
<tr>
<td>Total cost of the construction</td>
<td>R$ 420,082.81</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table 2 shows, according to the service of reinforced concrete structure, which are the services that have been studied separately.

**Table 2 Reinforced concrete service**

<table>
<thead>
<tr>
<th>Services</th>
<th>Unit</th>
<th>Amount</th>
<th>Total (R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Fck 25 MPa</td>
<td>m³</td>
<td>91,50</td>
<td>39,698,30</td>
</tr>
<tr>
<td>Steel Frame ca-50, diam. 6.3 (1/4) to 12.5 mm (1/2) - Supply / cutting (10% loss) / fold / placement</td>
<td>kg</td>
<td>5,156,63</td>
<td>44,604,84</td>
</tr>
<tr>
<td>Shape for concrete structures in wooden plate</td>
<td>m³</td>
<td>510,10</td>
<td>15,609,06</td>
</tr>
<tr>
<td>Reinforced concrete structure</td>
<td>m³</td>
<td>43,44</td>
<td>99,912,20</td>
</tr>
</tbody>
</table>

The reinforced concrete structure service was accompanied in place to carry out the hand consumption measurements of work related to specific services, i.e., the consumption bricklayer, janitor, carpenter, and owner, counted in hours worked, with reference to the Unit Price composition of each service, making a comparison with what was planned and what was consumed, offering subsidies to classify and characterize the loss of manpower.

Following the compositions adopted for the work of the case study, as it was engaged between the construction company and the Municipality of Salgueiro / PE, specifically the labor consumption items.

**Table 3 Composition of the service for concrete Fck 25 MPa**

<table>
<thead>
<tr>
<th>Concrete Fck 25 MPa produced in the construction (m³)</th>
<th>Unit</th>
<th>Expected amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mason</td>
<td>h/m³</td>
<td>1,62</td>
</tr>
<tr>
<td>Serve Mason assistant</td>
<td>h/m³</td>
<td>7,62</td>
</tr>
</tbody>
</table>
From the consumer compositions of labor items (expected) were recorded in timekeeping, the consumption in on-site, systematized from the service that each employee was performing the specific services of the reinforced concrete structure, it was considered only the daily working hours, between 7:00 am until 5:00 pm, with lunch break from 11:00 am to 12:00 pm.

In quantifying the losses involved in the consumption of labor in relation to the service that is playing, the research project used a framework, from the deviation found in service, it is the proposed improvement in a particular case, according to Table 6.
4.0 RESULTS

In carrying out the on-site survey, we obtained measurements of time involved in the production process, they were quantified and characterized, ie description of the activity performed by the worker on the determined time.

For the service of reinforced concrete structure, comprising the structural concrete serum (delivery and implementation), wood formwork and steel reinforcement; thus obtained the following final result, as shown in Table 7.

Table 7 Chart of deviation identification and percentage

<table>
<thead>
<tr>
<th>Labor</th>
<th>Unit</th>
<th>Expected Consumption</th>
<th>Real Consumption</th>
<th>Deviation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mason</td>
<td>hour/m³</td>
<td>1,62</td>
<td>2,90</td>
<td>79,01% (Loss)</td>
</tr>
<tr>
<td>Mason assistant</td>
<td>hour/m³</td>
<td>7,62</td>
<td>13,89</td>
<td>82,28% (Loss)</td>
</tr>
<tr>
<td>Carpenter</td>
<td>hour/m²</td>
<td>1,50</td>
<td>2,0</td>
<td>33,33% (Loss)</td>
</tr>
<tr>
<td>Carpenter Assistant</td>
<td>hour/m²</td>
<td>1,50</td>
<td>3,0</td>
<td>100% (Loss)</td>
</tr>
<tr>
<td>Frame layer</td>
<td>hour/kg</td>
<td>0,097</td>
<td>0,055</td>
<td>43,30%</td>
</tr>
<tr>
<td>Frame layer assistant</td>
<td>hour/kg</td>
<td>0,097</td>
<td>0,060</td>
<td>38,14% (profit)</td>
</tr>
</tbody>
</table>
It is noticed that the loss percentage of labor is higher for mason helpers and carpenter. The bricklayer’s assistant, responsible for various tasks during the structural concrete service (delivery and implementation), which involves collection of materials, shipping, handling (mix concrete), launch, consolidation, cleaning, etc; however, it was found that the waiting time involved in the service are significant for this type of professional.

The loss percentages stands out for the helper, checked from the observation sheets, which follows in this appendix, the causes of the losses, except for the frame layer’s assistant, in order that the consumption coefficient of this worker was expected the cutting and bending services, but the constructor decided after to acquire steel already cut and bended according to the structure project, causing a decrease of 38.14% helper consumption and 43.30% for the owner.

Besides the results of manpower losses, it was verified the financial impact, with new consumption coefficients. Thus, considering the unit price of workers (R$ / hour worked), seen in Table 08.

Table 8 Chart for identification of financial impact in the construction

<table>
<thead>
<tr>
<th>Labor</th>
<th>Unit</th>
<th>Deviation (%)</th>
<th>Financial Impact R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mason</td>
<td>hour/m²</td>
<td>79.01% (loss)</td>
<td>R$ 1.542,47 (loss)</td>
</tr>
<tr>
<td>Mason assistant</td>
<td>hour/m²</td>
<td>82.28% (loss)</td>
<td>R$ 5.691,15 (loss)</td>
</tr>
<tr>
<td>Carpenter</td>
<td>hour/m²</td>
<td>33.33% (loss)</td>
<td>R$ 3.359,01 (loss)</td>
</tr>
<tr>
<td>Carpenter assistant</td>
<td>hour/m²</td>
<td>100% (loss)</td>
<td>R$ 7.590,29 (loss)</td>
</tr>
<tr>
<td>Frame layer</td>
<td>hour/kg</td>
<td>43.30% (profit)</td>
<td>R$ 2.852,34 (positive deviation)</td>
</tr>
<tr>
<td>Frame layer assistant</td>
<td>hour/kg</td>
<td>38.14% (profit)</td>
<td>R$ 1.892,69 (positive)</td>
</tr>
</tbody>
</table>

5.0 CONCLUSIONS

In qualitative and quantitative analysis of the results obtained in the construction, university of the study case, the Project that involves research concluded the following results:

I) the assistants were the professionals who had a higher deviation between the expected consumption with the real consumption due to higher displacements within the construction site, as a result of charge transport tasks, either of inputs and/or tools;

I) the services that depend on higher labor consumption and a small grade of industrialization are more susceptible to the occurrence of negative deviation in labor, causing financial loss for the particular item
III) the acquisition of steel bent and cut, according to project demand the acquisition of steel bent and cut, according to project demand, allowed a reduction of labor consumption by 40.72%, whereas the average between the frame layer and his helper;

IV) the non-verification of the expected consumptions and the real ones during the construction allow the continuity of the existing mistakes, by not finding the event, much less by the inaction to solve; and

V) it is necessary the appreciation of the process of planning and management of the constructions by the construction companies and the government also

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Cost evaluating of engineering solution in a public work through parametric estimating - Case Study

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ABSTRACT

During public works auditing, sometimes the lack of time or information not allows to use traditional techniques in order to evaluate with accuracy whether engineering solution adopted by institution supervisioned is reasonable or not. In this situation, parametric estimating could be an option. This case study presents a real case of a public work supervisioned by Office of the Comptroller General (Controle-Geral da União - CGU) in 2015, in which was possible ascertain the inadequacy of an engineering solution adopted, and overcost stem from this, using date of square meter cost of constructions. The overcost was calculated using dates extracted from Sinduscon's table and applying technics of polynomial regression to obtain a formula of total cost construction per number of floor. This function was used to compare the solution chosen by institution under fiscalization with alternatives. It was possible conservatively to concluded by an overcost of more than nine hundreds of thousands reais (about two hundred and fifty thousand dollars). This study shows that it is possible using this method to ascertain if the engineering solution is adequate when it has not date or time enough to calculate the total cost construction in the accurate way.

Keywords (no more than 5): Overcost, polynomial regression, cost estimating, public works.

1 INTRODUCTION

In Brazil, the huge demand for investments in many sectors is well-known, mainly infrastructure, healthy and education, being these sectors basics for national economic growth. In the educational sector, the Brazilian Government created a program, by Decree nº 6.096, of April 24, 2007 (BRASIL, 2007) with the aim of duplicating numbers of available vacancies for students in higher education. This program received more than 1,9 billions of reais (about five hundred and forty dollars) in 2012. Nonetheless, the demand for investment in all areas is bigger than public funds available.

Because this, the Law nº 8.666, of June 21, 1993 (BRASIL, 1993), responsible for regulation of public bidding, it requires previous study to demonstrate that, among others alternatives, the adopted solution is the most advantageous.
Despite of the law requirement, in Brazil, not rarely, processes are found without preliminary studies. This missing is strongly criticized by control agencies, because this technical document is the main evidence that explains for what reason the adopted solution is the best compared with other alternatives.

The Brazilian internal control is performed by Ministry of Transparency, Fiscalization and Control (Ministério da Transparência, Fiscalização e Controle - MTFC) that replaced the Office of the Comptroller General (CGU) in 2016.

During the activities developed until then by CGU in 2015, an educational institution was supervisioned about resources application from the program called The Restructuring and Expansion of Federal Universities (Restruturação e expansão de universidades federais – REUNI). The supervisioned institution's name will not be mentioned here to avoid an unnecessary exposition.

The students, who have claimed improving in the university structure, were pressuring the university, once the classes was occurring in a rented school without adequacy infrastructure. At that time, the institution had promoted a bidding to construction a university building, but had serious problems during execution, what it resulted in the contract interruption.

After the contract interruption, the university needed a fast solution in order to restart the work and offering an answer to student’s demands. Then, managers decided to adopt the project had already used in other building, to spend less time in elaborating and approving it.

However, the project had a two-story building, insufficient to meet the needs of academic community that it has needed three-story building. This change required to elaborate new executive projects, what it would demanded about three months, according managers. Despite of the time demanded, the academic community agreement with proposed schedule.

Even so, the staff have decided to construct two two-story building, instead of only one building with three or four-story. Moreover, it has not done any preliminary study to compare possible solutions, justifying merely case urgency.

In this situation, estimating the damage promoted by the adopted solution is crucial, because otherwise only a formal missing would be appointed and it would not have an order-of-magnitude of seriousness of the mistake.

The detailing of overall cost by summing of cost of each work's element is the method more accuracy for evaluating the solution cost. However, elaborating all projects and its budgets would demand months, time not available in most of auditing case.

This case study presents the results of a supervision developed by then Office of the Comptroller General where it was identified that the adopted engineering solution by the supervisioned institution was seriously disadvantageous.

In order to ascertain how much disadvantageous was the adopted solution, it was used as input data
basic unit costs published by Syndicate of Industry and Commerce (Sindicato da Indústria e Comércio - Sinduscon). Through of curve fitting, it can be obtained an equation that it offers cost per square meters in function of number of story building.

The equation output allows to concluded conservatively that decide of constructing two two-story building was more expensive than building only one with three-story in about nine hundreds of thousands reais (about two hundred and fifty thousand dollars).

This paper is structured in seven chapter, beginning for this introduction. In the sequence, it is addressed the Brazilian law requirement about preliminary studies. The Chapter 3 comprises the basic aspects about Sinduscon’s data. The adopted engineering solution by the supervisioned institution is detailed in the Chapter 4. Then, in the Chapter 5, it is presented the parametric estimating realized, including specific data used and the equation obtained. The comparison of the cost of the two solutions is presented in Chapter 6, followed by conclusion in the Chapter 7.

2 REQUIREMENTS of preliminary studies

The article 6, item IX, of Law nº 8.666, of June 21, 1993 (BRASIL, 1993), states project as set of necessary and sufficient elements, with adequate precision level, to characterize the work, prepared based on indications of preliminary technical studies to ensure feasibility, enabling assessment of the cost, beyond other things.

Despite of prediction legal, there is not legal description of the minimal content in preliminary technical studies. According Campelo (2014), the feasibility study begins with the needs assessment. After the need is defined, the same author recommends to compare various technical approaches that can be taken, each one with their cost estimating.

The lack of preliminary technical studies has resulted in reproof by control agencies, as the decision nº 2687/2008 of the Brazilian Federal Court of Accounts (TCU, 2008), and it was one of failures identified during auditing process in this case study.

Probably, if the solution adopted by institution were the best economically, the lack of preliminary technical studies, in general, would not have major consequences. The acceptance of absence of preliminary studies, when the adopted solution is reasonable, it might be a reason for managers, in general, do not take enough care with this obligation.

Because this, even those cases where the adopted solution is the best, control agencies are demanding that the preliminary studies must be presented.

3 MOTIVATION AND DETAILS OF ENGINEERING SOLUTION ADOPTED

The work contracted aims to construct the first building in the federal university campus located in a country city and, until now, was necessary to promote two bidding. The academics activities started in August 2010, but the first bidding to construct the campus building occurred only in October 2010.
The work begins in February 2011, but the company did not comply with its commitments and the contract was paralysed in June 2011. Later, in August 2012, it was terminated. After this, the managers have claimed that the project no longer met academic needs and have decided to restart the work with another project. Because this, all service accomplished was waste. This first construction had predicted 2.691.21 m² through four blocks, totalizing R$ 2.551.721,44, but only the foundation was executed.

In the second attempt, the managers choose to use a project have already accomplished in other campus, once have already passed three years since the beginning of academic activities and the students and professors have claimed a fast solution.

However, the selected building to be constructed had only two-story, what it was insufficient for academic needs. So, it was decided to add one-story in the project. According to the staff, this changing would require about three months at least. Even thus, the changing was accepted in March 2014 by academic community.

One month later, in order to save time, they decided to go back and to construct two two-story-building, instead of one with three-story, without preliminary studies comparing the two solutions, what led to misuse of public funds.

Although the academic community needed of a building with three-story totalizing an area of 2.430 m², because of adopted solution with two buildings, at the final of the work, it will be provided an area of 3.240 m², investing an amount of money higher than necessary.

However, it is well known that public funds are limited and the public demands are unlimited. The resources applied in an unnecessary way, in this case, are almost equal to amount of investment needed to construct a university restaurant, other claiming from academic community.

The accuracy way to calculate how much resources were misused, it would be require preparing all projects and its budgets for the three-story building and then compare with overall cost of adopted solution. Once this possibility is not feasible, it was used Sinduscon’s data to accomplish a parametric estimating and measure conservatively this damage.

4 SINDUSCON’S DATA

According law nº 4.591, of 16th December 1964, the Syndicate of Industry and Commerce (Sindicato da Indústria e Comércio - Sinduscon) must publish, until the fifth day of each month, the construction basic unit cost in each state (BRASIL, 1964).

The NBR 12.721:2006 (ABNT, 2006) establishes the methodology of construction unit cost, which it involves four groups of standard project: residential, office, popular residence and industrial shed. Among standards projects, in this case study, it was discarded popular residence and industrial shed, once their building characteristics were too different of public building studied.
Beyond this, the basic unit cost provided for office standard project, it includes only building with eight and sixteen-story what becomes inadequate its using because only buildings until four-story were studied.

Then, the basic unit cost of residence standard project was the most appropriate for parametric estimating in the present case. Residence standard has three levels of materials quality standard: low, normal and high. For each level, it provides unit cost for building with one, four, eight and sixteen-story, being the construction with four-story a popular building. In the curving fit only was considered residential building in order to keep resemblance among the characteristic of projects, so discarding the popular building datum. The Tab. 1 presents basic unit cost extracted from Sinduscon for database May 2014.

<table>
<thead>
<tr>
<th></th>
<th>RESIDENCE STANDARD</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOW</td>
<td>NORMAL</td>
<td>HIGH</td>
<td></td>
</tr>
<tr>
<td>R-1</td>
<td>R$ 1.028,13</td>
<td>R$ 1.242,35</td>
<td>R$ 1.616,61</td>
<td></td>
</tr>
<tr>
<td>PP-4</td>
<td>R$ 979,55</td>
<td>R$ 1.168,89</td>
<td>R$ 1.318,52</td>
<td></td>
</tr>
<tr>
<td>R-8</td>
<td>R$ 931,46</td>
<td>R$ 1.029,39</td>
<td>R$ 1.340,82</td>
<td></td>
</tr>
<tr>
<td>PIS</td>
<td>R$ 709,68</td>
<td>R-16</td>
<td>R$ 1.012,20</td>
<td></td>
</tr>
</tbody>
</table>

Legend: R: residence, PP: building popular, PIS: social interesting project. Ex: R-8: residence with eight-story.

Moreover, it is important to highlight that the basic unit cost, provided by Sinduscon, it's a project-based cost factors, but do not consider cost related with foundation, equipment, elevator, preparing projects, fee, tax, profit, among other things.

5 PARAMETRIC ESTIMATING and curve fitting

Parametric cost estimating, second HQUSACE (2010), “is an intermediate-level estimate performed when design drawings are typically between 10% and 35% complete”. This same author explain that “the parametric costs are based on assemblies or systems grouping the work of several trades, disciplines and/or work items into a single unit for estimating purposes”. In this present study, as reported previously, the parametric cost used is basic unit cost (CUB) published monthly by Sinduscon.

Nevertheless, the Sinduscon provides data only for residence building with one, eight and sixteen-story. For this reason, the polynomial regression method was used in order to obtain an order-of-magnitude of overall cost for buildings with two, three and four-story.

Once that the budget of the two-story building had already been concluded, it was assumption, conservatively, that the budget to be estimated had already been finished at least 40%. In this case, according the cost estimate classification matrix (AACE, 1997), this estimating is associated with Class 3 or higher. Therefore, the expected accuracy range is from -10% to +30%. This range is used later to rectify possible excess in the curve fitting outcomes.
The curve fitting, also known as regression analysis, is a method used to find the “best fit” line or curve for a series of data points. Among regression models, the polynomial regression was considered here. According Rawlings et al. (1998), this regression class allows greater flexibility and realism by introducing the higher-degree polynomial models.

In this case, it was assumed quadratic relationship between a dependent variable (basic unit cost) and an independent variable (number of floors), what result in a second-order polynomial model that it has the following generic expression:

\[ C(n) = \beta_0 + \beta_1 n + \beta_2 n^2 \]  

being \( C(n) \) the basic unit cost, \( n \) the number of floor related, \( \beta \) coefficients to be obtained. Using the data, for normal standard residence (R-1, R-8 and R-16), given in Tab. 01 as input in equation (1), it can obtain three equation:

\[ 1.242,35 = \beta_0 + \beta_1 1 + \beta_2 1^2 \]  
\[ 1.029,39 = \beta_0 + \beta_1 8 + \beta_2 8^2 \]  
\[ 1.012,20 = \beta_0 + \beta_1 16 + \beta_2 16^2 \]  

The system of equations (2), (3) e (4) can be express by matrix equation given by:

\[ \begin{bmatrix} 1.242,35 \\ 1.029,39 \\ 1.012,20 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 8 & 64 \\ 1 & 16 & 256 \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \end{bmatrix} \]  

The system can be solved using the inverse of the coefficient matrix:

\[ \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \end{bmatrix} = \begin{bmatrix} 1,219048 & -0,228571 & 0,009524 \\ -0,228571 & 0,303571 & -0,017867 \\ 0,009524 & -0,017867 & 0,008333 \end{bmatrix} \begin{bmatrix} 1,242,35 \\ 1,029,39 \\ 1,012,20 \end{bmatrix} \]  

Thus, the obtained equation by polynomial regression has correlation coefficient (R²) equal a one and the following form:

\[ C(n) = 1.287,85 - 47,3873X + 1,8849X^2 \]  

The Fig. 01 presents the graphic of equation (7), where it can be realized that the curve plotted presents basic unit cost next of 10 floor shorter than 16-story, what is unhoped in usual conditions. However, this behavior do not compromise the outcomes, once the used data are for two, three and four floor, before the interval related, and the outcomes are later reduced for rectifying possible haziness.
In order to validate the obtained equation, it is calculated the basic unit cost for two-story building by equation, what it outcomes in R$ 1,200,61 per square meter, and then it is compared with cost per square meter of budget available, what it totalizes R$ 1,055,33. It is highlighted the need of disconsider costs not counted in CUB, as foundations, projects, profit, taxes, external area, and other elements. By outcomes, it is realized that equation is conservative and it provides a cost 12,10% higher real cost, value reasonable for estimation purposes. The work budget summary is presented in Tab. 2.
### Table 2 Work budget summary for the main services groups.

<table>
<thead>
<tr>
<th>Services</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Executive projects</td>
<td>R$ 29,822,37</td>
</tr>
<tr>
<td>2. Preliminary services: Building site, cleaning, etc.</td>
<td>R$ 42,668,76</td>
</tr>
<tr>
<td>3. Foundation and reinforced concrete structure</td>
<td>R$ 395,216,04</td>
</tr>
<tr>
<td>4. Masonry wall</td>
<td>R$ 44,140,66</td>
</tr>
<tr>
<td>5. Masonry work: plaster, , etc.</td>
<td>R$ 132,806,67</td>
</tr>
<tr>
<td>6. Floor services</td>
<td>R$ 151,148,88</td>
</tr>
<tr>
<td>7. Doors, windows, glass, grid, etc.</td>
<td>R$ 204,494,20</td>
</tr>
<tr>
<td>8. Trussed roof</td>
<td>R$ 109,331,41</td>
</tr>
<tr>
<td>9. Painting</td>
<td>R$ 152,418,59</td>
</tr>
<tr>
<td>10. Installation of plumbing and sanitary system</td>
<td>R$ 50,729,18</td>
</tr>
<tr>
<td>11. Installation of electrical system</td>
<td>R$ 162,884,65</td>
</tr>
<tr>
<td>12. Minor services</td>
<td>R$ 106,311,81</td>
</tr>
<tr>
<td>13. External services</td>
<td>R$ 10,631,14</td>
</tr>
<tr>
<td>14. Cleaning</td>
<td>R$ 1,618,33</td>
</tr>
<tr>
<td>15. Installation of fire protection system</td>
<td>R$ 31,632,63</td>
</tr>
<tr>
<td>16. Installation of telephone system</td>
<td>R$ 2,483,24</td>
</tr>
<tr>
<td>17. Installation of lightning protection system</td>
<td>R$ 15,005,38</td>
</tr>
<tr>
<td>18. Construction management</td>
<td>R$ 295,701,12</td>
</tr>
<tr>
<td><strong>SubTotal</strong></td>
<td><strong>R$ 1,939,063,06</strong></td>
</tr>
<tr>
<td><strong>Indirect costs, taxes, profit (25.86%)</strong></td>
<td><strong>R$ 501,441,71</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>R$ 2,440,504,77</strong></td>
</tr>
</tbody>
</table>

### 6 Comparing Solution

Through the equation (7), one can obtain the basic unit cost of a building in function of number of floor, as presented in Tab. 3.

**Table 3 The basic unit cost in function of number of floor.**

<table>
<thead>
<tr>
<th>Number of floor</th>
<th>Estimated Cost per square meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>R$ 1,200,61</td>
</tr>
<tr>
<td>3</td>
<td>R$ 1,162,64</td>
</tr>
<tr>
<td>4</td>
<td>R$ 1,128,44</td>
</tr>
</tbody>
</table>
The two building to be constructed by supervisioned institution has each one two floor with both the same 810 m². Thus, using data presented in Tab. 3, one can use total area of each building and estimating the construction overall cost, as presented in Tab. 4, considering a percentage of 25.86% of indirect costs, profit, taxes, etc. Highlighting, one more time, that the estimated construction overall cost not consider some cost as foundation.

**Table 4** Estimated construction overall cost in function of number of floor.

<table>
<thead>
<tr>
<th>Number of floor</th>
<th>Area</th>
<th>Global estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.620 m²</td>
<td>R$ 2.447.962,14</td>
</tr>
<tr>
<td>3</td>
<td>2.430 m²</td>
<td>R$ 3.555.815,85</td>
</tr>
<tr>
<td>4</td>
<td>3.240 m²</td>
<td>R$ 4.601.624,85</td>
</tr>
</tbody>
</table>

Thus, comparing the outcomes, it can be concluded, in a context of feasibility analysis, that an engineering solution with two two-story building is more expensive than a solution with one four-story building in about R$ 294,283,13. On the other hand, knowing that the actual need of institution is a three-story building, this overcost rises to R$ 1,340,101,31.

Once the estimated value was obtained by parametric estimating, it is reasonable to reduce the outcomes in 30% to rectify possible haziness of parametric estimating, acting in favour of supervisioned institution, resulting in an overcost of R$ 205,998,19, in the first situation, and R$ 938,070,91 in the worst case. The Fig. 2 presents, after reduction, the estimated overall cost for each solution.

**Figure 2** Estimated overall cost for possible solution after reduction of 30% to rectify inaccuracy.
This way, it was considered conservative assumptions to ensure that the estimative was not too excessive. But, even thus, it was possible identify a large damage to public funds stems from an engineering solution more expensive than necessary.

7 CONCLUSION

It was presented the results of an ascertaining developed by Office of the Comptroller General (Controle-Geral da União - CGU) in 2015, aiming to verify resources application from the program called the Restructuring and Expansion of Federal Universities (Restruturação e expansão de universidades federais – REUNI).

The supervisioned institution decided to construct two building with two floor, while the identified demand pointed a needing of only one three-story building. The accuracy way to measure the overcost stems from this decision was to prepare all executive project, what was unavailable in schedule audit.

Therefore, it was used Sinduscon’s data to obtain an equation, by polynomial regression, which offered the basic unit cost in function of number of floor and, with total area of each solution; it was possible to compare the feasibility of each one. Indeed, in order to rectify possible inaccuracy stems from parametric estimating, the outcomes were reduced in 30%.

Thus, it could be concluded that to construct two building with two floor was more expensive than only one building with four-story in R$ 205.998,19. Moreover, comparing the adopted solution with the demand identified as sufficient by academic community, one three-story building, the overcost reached to R$ 938.070,91.

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Evaluating the Cost of Disruption in Office Retrofit Building Projects

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**ABSTRACT**

**Purpose of this paper (mandatory)**

The purpose of this paper is to evaluate the cost of disruption in office retrofit building projects.

**Design/methodology/approach (mandatory)**

This work adopts a positivist approach and evaluates the cost of disruption based on the estimated level of disruptiveness of retrofit technologies. Different Building Configuration Permutations (BCPs) in two recent case study projects – A and B, are developed. The cost of disruption in the projects are estimated as a proportion of the staffing and business operating cost in respective organisations.

**Findings and value (mandatory)**

It was found that the average cost of disruption in Project A can lead to an additional cost of 2 – 12%, relative to the initial capital cost; and the average cost of disruption in Project B can lead to up to 0.2 – 1.5%, relative of the initial capital cost.

**Research limitations/implications (if applicable)**

The research focused on only two case study projects. It will be helpful for further work to examine the cost of disruption in larger samples of office retrofit building projects, and also develop alternative approaches to evaluating the cost of disruption.
Practical implications (if applicable)

An understanding and accurate evaluation of the cost of disruption in office retrofit building projects will enhance the robustness in the cost estimates of retrofit scenarios, and will prove invaluable in improving the whole-life cost assessment of retrofit buildings.

Originality/value of paper (mandatory)

The paper has evaluated the cost of disruption in selected retrofit projects and this information will assist property developers and investor in better understanding the economic implication of office retrofit projects. This work will also aid the development of cost models, specific to retrofit scenarios.

Conclusions:

Based on the case study projects, it was found that the added cost of disruption can increase the initial cost of acquisition of retrofit options by up to 1.5% and 12% in Project A and Project B respectively.

Keywords: cost, disruption, fuzzy-logic, retrofit

1 introduction

Retrofit initiatives are considered primarily as energy conservation measures (ECMs) used to promote building energy-efficiency and sustainability (Ma et al., 2012). Foley (2012) asserted that many buildings in the developed countries, particularly those constructed in the pre-1960 years, are in need of retrofitting. According to Birchall et al., (2014), the highest proportion of office buildings in the UK were constructed in pre-1945 years. There is however a need to focus on office buildings, as the potential for cost savings are on average, higher than in many of the other building typologies. Moreover, Dixon et al., (2014) argues that office buildings along with other commercial properties are under-researched with regards to energy-efficient retrofit measures.

The retrofitting of office buildings in the UK is estimated to achieve a potential cost savings of £1.6 billion (Dixon et al., 2014). In the UK, the average floor area per unit of office buildings are about four times larger than residential units. It is however noteworthy that over half of commercial properties are rented, compared to only a third of residential building space. The situation with office buildings suggests that the long-term interests in buildings tend to be of lesser concern to building occupants.

2 Disruptiveness of retrofit technologies

Retrofit technologies in buildings help in achieving savings from energy-use, through harnessing opportunities for alternative energy generation. Retrofit initiatives can be classified into supply-side and demand-side retrofit initiatives.

Supply-side retrofit initiatives are primarily concerned with the use of alternative energy sources in order
to provide electricity, and thermal energy for buildings. In retrofit projects, upgrading energy-conversion plants, or replacing inefficient energy-conversion plants, could assist in satisfying the energy-needs of buildings, in a more environmentally-friendly, cost-efficient, and sustainable manner (Foley, 2012). Supply-side management initiatives involve the use of alternative energy sources such as solar photovoltaic (PV) systems, wind, biomass, fuel cell, geothermal and combine heat and power systems (Ma et al., 2012).

Demand-side retrofit initiatives consist of technical and behavioural strategies embraced to minimise the building's heating and cooling demand, and involve the use of energy-efficient equipment, and low energy appliances (Ma et al., 2012). Technical aspects of minimising the heating and cooling demand of buildings, involve procedures such as draught-proofing, insulation-enhancement and improving the performance of building fabric (Williams, 2012). Behavioural aspects of minimising the heating and cooling demand of buildings include procedures such as changing individual behaviours, and the inclusion of specialised equipment, that can potentially enhance the thermal envelop of buildings (Robert, 2008).

Investment in retrofit scenarios tend to involve some level of disruption to the normal operation of building occupants (Dixon et al., 2008, Thomsen et al., 2009, Gleson et al., 2011, Menassa, 2011). Depending on the scale of this disruption, this could significantly alter the business case of the entire project. Verbruggen et al., (2013) argues that disruptive decisions tend to have disproportionate impacts and hence, a good cataloguing of outcomes will be essential. Gleson et al., (2011) conducted a disruption analysis on the installation of the listed retrofit interventions (see Table 1 below), and provided a 3-scale assessment of Low (L), Medium (M), and High (H) levels of disruptions. Given the different retrofit configurations that could be adopted in a building, it will be helpful the consider the effects and cost of disruption prior to sanctioning a retrofit option. The evaluation of the cost of disruption to profit-earning activities in buildings under retrofitting have however not been considered in existing investment appraisal literature. Perhaps one explanation for this is that, traditional cost models have mainly focused on new buildings, in which case the cost of disruption is rather absent, and need not considered.

Table 1: Disruption levels of common retrofit interventions

<table>
<thead>
<tr>
<th>Disruption Level</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Retrofit Interventions in Buildings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compact Fluorescent Lamp</td>
<td>Boilers and Controls</td>
<td>Heat Pumps</td>
<td></td>
</tr>
<tr>
<td>Draught Excluders</td>
<td>Solar Hot water cylinder</td>
<td>Internal wall insulation</td>
<td></td>
</tr>
<tr>
<td>Cavity Wall Insulation</td>
<td>Solar thermal systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot water tank Insulation</td>
<td>Replacement of windows and doors</td>
<td>Ground Floor Insulation</td>
<td></td>
</tr>
</tbody>
</table>
Given the relative energy-inefficiency of existing buildings, and the limited amount of Greenfield sites in choice locations, retrofitting and refurbishment projects could become more alluring to building owners and property experts. Another possible explanation for failure to evaluate the cost of disruption in buildings might be due to the high level of imprecision in the effects of disruptive technologies. This implies that disruption in buildings tend to highly variable, and perhaps unpredictable in certain buildings. The nature of disruption also tends to vary significantly depending on the quality of construction, use and misuse by the current or previous occupiers, flexibility in the original design, and the age of the building.

3 RESEARCH METHODOLOGY

One possible approach to estimating the cost of disruption in office buildings, is on the basis of opportunity costs. However, it can be expected that many offices will not fully suspend business operations simply to embark on a retrofit project, except in a perceived emergency. In such a scenario, the opportunity costs may be the extra costs incurred in securing an alternative temporary location, over the course of the retrofit building work. The limitation of this approach is it assumption of full disruption in business operations, which might not be the case. For example, changing light bulbs to energy-efficient compact fluorescent lamps (CFL) in an office could save up to 10% of its energy cost (Duffy et al., 2015) without expressly disrupting business operations in an office building. Equally, the ‘opportunity cost’ approach will not adequately appraise the effects of relocation on business prospects, patrons and staff of the organisation.

A suggested approach to evaluating the cost of disruption, which better considers varying potentials of disruption in respective scenarios is to estimate the actual costs of running the office building, based on the maintenance and building operating cost and staff cost. Hughes et al., (2004) based on published data proposed a 1: 0.4: 12 ratios for the Construction cost, to Maintenance and Building Operating Cost, to Staffing and business operating costs, for commercial office buildings, over an estimated period of 25 years. A proportion of the staffing and business operating cost provides a numerical basis for estimating the cost of disruption in respective retrofit scenario. This approach may however be considered preferable to the ‘opportunity cost’ approach, as information on the possible days of disruption could be more easily harnessed. This approach is also specific for particular retrofit packages, and could be useful for comparative purposes.

The subjective and linguistic data available in appraising disruptiveness of retrofit technologies will suggest that fuzzy logic techniques, along with other qualitative evaluation techniques, offer a useful means of evaluating the cost of disruptiveness of retrofit technologies. The benefits of fuzzy logic lie in its capacity to accommodate subjective input parameters (Zadeh 1995, Ammar et al., 2013). Hence, linguistic variables could be converted into membership values. Previous work by Fayek and Sun (2001) have utilised linguistic variables in describing factors affecting a construction project. Zadeh (2008) asserts that linguistic descriptors are perhaps one of the most powerful application of the fuzzy logic technique. Arena (2014) however, advised that Dempster-Shafer and Evidence theory, are better poised at dealing with ignorance and lack of knowledge in systems, rather than evaluating subjective knowledge.
This study will therefore examine and evaluate, the disruption cost of retrofit technologies based on fuzzy logic techniques.

This work has developed a factor chart analysis for evaluating the cost of disruption of retrofit technologies. It is reasonable to assume that the actual level of disruption will be moderated by project management considerations. The Factor Chart analysis proposes a logical approach to implementing retrofit solutions in buildings. The factors potentially affecting the disruption of business operations have been mindfully selected to reflect the internal relationship between retrofit mechanism. In Figure 1, five levels are hierarchically constructed as Goal: Level 1; Mechanism: Level 2; Focus: Level 3; Sub-Focus: Level 4; and Indication: Level 5. This approach draws from previous risk/revenue evaluation framework by Ayyub (2006).

Figure 1: Factor Chart Analysis for Disruption Cost Evaluation in Office Retrofit Buildings
In this work, the cost of disruption is considered a fuzzy variable, and will depend on the nature of operations of the current building occupants. In order to apply the principles of fuzzy logic, it will be necessary to define the tolerance values specified by Ayyub (2006) in evaluating the respective cost of disruption.

The max-min composition is commonly used when a system requires a conservative solution. Loetamonphong and Fang (2001, pp6) explained this approach as when the "goodness of one value, cannot compensate the badness of another value".

Mathematically, the max-min composition is a fuzzy logic formulation, and the structural equation modelling used for evaluating the cost of disruption can be represented as:

\[ \mu_{\text{C}}(x) = \min \{ \mu_{\text{A}}(x), \mu_{\text{B}}(x) \} \]

Eqn 1.1

Figure 2 shows a graphical illustration of the max-min composition. In Figure 2, the minimum value of two normal distributions, \( A_1 \) and \( B_1 \), are combined to produce a distribution \( C_1 \). The minimum of \( A_2 \) and \( B_2 \), are also combined to produce a distribution \( C_2 \). The maximum of distributions \( C_1 \) and \( C_2 \), then produces the distribution \( C' \), which is effectively the final aggregated value of the max-min composition. Ross (2009) pointed out that the max-min composition is analogous to approximate reasoning using the IF-THEN rules.
Table 2: Tolerance values for different levels of disruption

<table>
<thead>
<tr>
<th>Run</th>
<th>0</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1.0</td>
<td>0.9</td>
<td>0.7</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
<td>0.7</td>
<td>0.9</td>
<td>1.0</td>
<td>0.9</td>
<td>0.7</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>High</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
<td>0.7</td>
<td>0.9</td>
<td>1.0</td>
<td>0</td>
</tr>
</tbody>
</table>

The disruption of each retrofit initiative on the overall cost is embodied in vague measures of Low, Medium and High, and will be considered as corresponding to lambda-cut values of 0.2, 0.5 and 0.8, in accordance with the work of Ammar et al., (2013) and represent levels of disruption, and provide a measure of uncertainty in each retrofit option. Based on the lambda-cut value of 0.5, the membership function of a retrofit initiative with Medium disruption can be expressed as:

$$\mu_{0.5} = \frac{1.0}{0.5} + \frac{0.9}{0.6} + \frac{0.7}{0.7} + \frac{0.4}{0.8}$$  \hspace{1cm} \text{Eqn 1.2}$$

Also, the membership function of a retrofit initiative with High disruption, based on the lambda-cut value of 0.8, will be expressed as:

$$\mu_{0.8} = \frac{0.7}{0.8} + \frac{0.9}{0.9}$$  \hspace{1cm} \text{Eqn 1.3}$$

Gleeson et al., (2011) reckoned that the disruption days for Low, Medium and High will correspond with, up to 2 days, up to 5 days, and up to 10 days. The general approach used in this work is illustrated in the case study projects. Gleeson’s work is however, based on the disruption level, in typical UK house building, which is a two-storey dwelling, and has a total floor area of 96m$^2$. To adopt this data, for office buildings, the disruption values will have to be normalised. Normalisation will effectively scale up, or scale down, the days of disruptions, based on the size of the building, as realistically as possible. Each of the retrofit initiative will then be aggregated. Since the disruption level of each retrofit initiative is represented as a lambda-cut set. An illustration of this can be shown in Figure 2
The disruption level for fabric measures, and efficient appliances, in Retrofit Initiative R\(_1\), will be estimated based on the disruption values, provided by Gleeson et al. (2011).

\[
\mu_{\text{Floor Insulation}} = \left[ \begin{array}{c} 1.0 \\ 0.9 \\ 0.7 \\ 0.4 \\ 0.5 \\ 0.6 \\ 0.7 \\ 0.8 \end{array} \right] \times 5 \text{ days}
\]

\[
\mu_{\text{Wall Insulation}} = \left[ \begin{array}{c} 0.9 \\ 0.7 \\ 0.2 \end{array} \right] \times 2 \text{ days}
\]

\[
\mu_{\text{Boiler}} = \left[ \begin{array}{c} 1.0 \\ 0.9 \\ 0.7 \\ 0.4 \\ 0.5 \\ 0.6 \\ 0.7 \\ 0.8 \end{array} \right] \times 5 \text{ days}
\]

\[
\mu_{\text{Disrupted days for Retrofit R}_1} = \left[ \begin{array}{c} 1.0 \\ 0.9 \\ 0.7 \\ 0.4 \\ 5 \text{ days} \\ 6.2 \text{ days} \\ 7.4 \text{ days} \\ 8 \text{ days} \end{array} \right]
\]

\[
\mu_{\text{Disrupted days for Retrofit R}_1} = [5 \text{ days, } 6.2 \text{ days, } 7.4 \text{ days, } 8 \text{ days}] \times [1.0, 0.9, 0.7, 0.4]
\]

\[
\mu_{\text{Disrupted days for Retrofit R}_1} = [(5d; 5.6d; 5.2d; 3.2d)]
\]

Using the Max-min composition operation, the Fuzzy Lower, Fuzzy Mean and Fuzzy Upper, for the number of disrupted days in Retrofit A, will now be computed as:

\[
\mu_{\text{Disrupted days for Retrofit A}} = [3.2 \text{ days, } 4.8 \text{ days, } 5.6 \text{ days}]
\]
The estimated number of days of disruption will be based on evaluating the contributions from respective retrofit initiatives, based on the Factor Chart analysis in Figure 1. The process adopted here in estimating the cost of disruption in office retrofit building projects, has certain limitations especially due to limited information, on the economic implication of disruption in retrofit projects. This approach is suggested in providing, an indicative estimate of the cost of disruption. It is however, advised that future studies should seek alternative ways of appraising the ‘cost of disruption’ in existing buildings.

The cost of disruption in this work is computed, by multiplying the cost of disruption for each day in the respective building, by the membership function for number of disrupted days in the retrofit initiative. Previous work by Hughes et al., (2004), estimated that, in commercial office buildings, the average proportion of “Staff and business operating cost” to “Maintenance and Building Operating Cost” is 30:1. A previous work by Evans et al., (2004) found that the average proportion of “Staff and business operating cost” to “Maintenance and Building Operating Cost” ratio is 40:1. Both works surmise that the ratios are estimated for a 25-year operational life.

In order to estimate the disruption cost, expenditures on Staff and business operating cost will have to be estimated. The Maintenance and Building Operating Cost per Year of the Retrofit A in the SPACE project is £143,800 (to nearest hundredth). The estimated Annual Staff and Business Operating Cost of Retrofit R1 can be estimated as $(30 \times £143,800) / 25 = £172,600$ (to nearest hundredth).

Assuming a 253 Working Day in a Year. The daily cost of disruption incurred in the Retrofit work for the SPACE project, is estimated to an equivalent sum of £680 per day.

For Retrofit R1, the cost of disruption can now be estimated as:

\[
\mu_{\text{Disrupted days for Retrofit R1}} = [3.2 \text{ days}, 4.8 \text{ days}, 5.6 \text{ days}] \times £680
\]

\[
\text{Cost of Disruption for Retrofit R1} (C_{d}) = [£2200, \ £3300, \ £3,800]
\]

The disruption cost of £2200, £3200 and £3800, correspond to the Fuzzy Lower, Fuzzy Mean, and Fuzzy Upper, cost of disruption. This implies that for the Retrofit R option, the overall cost of disruption could range between £2,200 and £3,800 in the course of installing the retrofit solutions.
4 CASE STUDY PROJECTS

Two case study retrofit projects (Project A and Project B) were selected to assess the cost of disruption in retrofit office buildings. Project A was first constructed as a 2-storey primary school during the 1930’s. It attained the status of a listed building in 2000, which suggests proposed retrofit interventions must take cognisance of the historic fabric, and any proposed alterations should be approved by the relevant planning department. Project A has been re-modelled and re-configured into a multi-tenanted office building, and has approximately 1800m$^2$ of net lettable area.

Project B is a masonry office building, and is originally built to comply with the United States ASHRAE 90.1 – 1989 building requirements. It is a 3-storey building, and has approximately 5,600m$^2$ of net lettable area.

Various retrofit building configuration permutations (BCPs) in Project A and Project B are developed using (IES<VE> and EnergyPlus) energy building simulation software programs. 10 BCPs are evaluated in Project A, and 22 BCPs are evaluated in Project B respectively. The cost of disruption of Project A and Project B are evaluated using fuzzy logic techniques. Table 3 and Table 4 reports on the cost of disruption in Project A and Project B respectively. By following on the approaches explained in the research methodology section, the results obtained in the projects are obtained.

5 RESULTS AND DISCUSSION

Table 3 sets out the estimated cost of disruption in Project A based on the fuzzy logic approach. The cost of disruption in Project A is can be up to £50,000.

Table 3: Estimated Cost of Disruption in Project A

<table>
<thead>
<tr>
<th>Run</th>
<th>Fuzzy Lower (£)</th>
<th>Fuzzy Mean (£)</th>
<th>Fuzzy Upper (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCP 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BCP 2</td>
<td>3,300</td>
<td>4,800</td>
<td>5,700</td>
</tr>
<tr>
<td>BCP 3</td>
<td>3,500</td>
<td>15,500</td>
<td>24,000</td>
</tr>
<tr>
<td>BCP 4</td>
<td>3,300</td>
<td>9,500</td>
<td>14,300</td>
</tr>
<tr>
<td>BCP 5</td>
<td>3,500</td>
<td>24,700</td>
<td>39,300</td>
</tr>
<tr>
<td>BCP 6</td>
<td>3,500</td>
<td>24,700</td>
<td>39,300</td>
</tr>
<tr>
<td>BCP 7</td>
<td>4,600</td>
<td>27,500</td>
<td>43,600</td>
</tr>
<tr>
<td>BCP 8</td>
<td>5,700</td>
<td>30,000</td>
<td>50,000</td>
</tr>
<tr>
<td>BCP 9</td>
<td>4,600</td>
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<tr>
<td>BCP 10</td>
<td>4,600</td>
<td>27,500</td>
<td>43,600</td>
</tr>
</tbody>
</table>
It can be observed from Table 3 that the average cost of disruption in Project A can lead to an additional cost of 2 – 12%, relative to the initial capital cost of the retrofit project. It is however unclear whether this cost is generalizable for other office retrofit projects. It can be expected that the cost of disruption in commercial office buildings will generally be higher than those of residential buildings of similar characteristics. There is however scope for further research regarding the evaluation of the cost of disruption in different building typologies. Table 4 reports on the estimated cost of disruption in Project B based on the fuzzy logic approach. The cost of disruption in Project B can be up to $55,000.

Table 4: Estimated Cost of Disruption in Project B

<table>
<thead>
<tr>
<th>Run</th>
<th>Fuzzy Lower($)</th>
<th>Fuzzy Mean ($)</th>
<th>Fuzzy Upper ($)</th>
</tr>
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<tbody>
<tr>
<td>BCP 1</td>
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<td>0</td>
</tr>
<tr>
<td>BCP 2</td>
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<td>0</td>
</tr>
<tr>
<td>BCP 3</td>
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</tr>
<tr>
<td>BCP 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BCP 5</td>
<td>6,200</td>
<td>15,500</td>
<td>25,000</td>
</tr>
<tr>
<td>BCP 6</td>
<td>8,200</td>
<td>18,000</td>
<td>28,000</td>
</tr>
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<td>8,200</td>
<td>18,000</td>
<td>28,000</td>
</tr>
<tr>
<td>BCP 8</td>
<td>1,900</td>
<td>2,900</td>
<td>3,300</td>
</tr>
<tr>
<td>BCP 9</td>
<td>8,200</td>
<td>18,000</td>
<td>28,000</td>
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<tr>
<td>BCP 1</td>
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<td>BCP 2</td>
<td>8,200</td>
<td>18,500</td>
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</tr>
<tr>
<td>BCP 3</td>
<td>10,000</td>
<td>21,000</td>
<td>31,500</td>
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<td>BCP 4</td>
<td>10,000</td>
<td>21,000</td>
<td>31,500</td>
</tr>
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<td>10,000</td>
<td>21,000</td>
<td>31,500</td>
</tr>
<tr>
<td>BCP 10</td>
<td>10,000</td>
<td>21,000</td>
<td>31,500</td>
</tr>
<tr>
<td>BCP 21</td>
<td>24,600</td>
<td>41,000</td>
<td>55,000</td>
</tr>
<tr>
<td>BCP 22</td>
<td>12,000</td>
<td>24,000</td>
<td>35,000</td>
</tr>
</tbody>
</table>

It can be observed from Table 4 that the average cost of disruption in Project B, can lead to an additional cost of 0.2 – 1.5% relative to the initial capital cost. It can be seen that these values, are comparatively smaller to the proportion seen in Project A. This could be a result of the building characteristics, including building size, orientation, scale of retrofit work, and the strategy employed in the retrofit project.
6 CONCLUSION

The cost of disruption is specific to existing buildings in which retrofit work is considered necessary rather than new builds and can vary significantly depending on the commercial interests of the respective organisation. It is expected that the cost of disruption will be more significant in goods-oriented organisation rather than service-oriented organisations, as the possibilities for relocation of production sites can be more difficult to arrange. It is also conceivable that the cost of disruption, on average, will be more significant in the private sector rather than the public sector. This is due to the profit-drive typical of private sector establishment. The organizational goals, the scale of operations of organisations owning office buildings, will also influence the magnitude and effect of the cost of disruption, in potential office retrofit building projects. An understanding and accurate evaluation of the cost of disruption in office retrofit building projects will enhance the economic appraisal of buildings and have great potentials in improving the whole-life cost assessment of building options. Based on the case study projects, it was found that the added cost of disruption can increase the initial cost of acquisition of retrofit options by up to 1.5% and 12% respectively in Project A and Project B. The approach to computing the cost of disruption in retrofit buildings, can be improved upon in future work. It will also be helpful for future work to examine the cost of disruption in larger samples of office retrofit building projects, as well as in other building typologies to better understand the economic implications of disruption.

7 REFERENCES


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Prioritization of Engineering Projects Using the AHP Multi-criteria Analysis

ABSTRACT

This paper seeks to compare the result of a unilateral decision-making process with the qualitative and quantitative process of the AHP multi-criteria analysis. To do so, research was carried out in the field of project management and multi-criteria analysis using an Analytic Hierarchy Process - AHP. The sources of research used to search for articles and books on the topic were Google Scholar, Scopus, and Scielo. The methodology chosen was a case study for the comparison proposed. The case study was carried out in a federal educational institution. As a result, it was possible to notice that objective and inter-related criteria can streamline administration and make it more assertive.

INTRODUCTION

Characteristics of the problem

Today, organizations are seeking ever more competitive advantages that put them on a plateau that is higher in relation to their competitors and by this reach margins of error that are increasingly smaller.

This quest for organizational excellence and its related activities has developed the area of project management, which in a generic way is able to operate in different branches of activity.

In order to increase the success rate of the projects, it is necessary to align them with the organization’s strategic planning. This alignment, when adequately done, aims to maximize the success of the projects carried out by the organization.

So it is necessary to exercise a certain degree of effort in selecting projects in order to ensure that the expectations are met that have been created by suppliers, shareholders, directors, customers, and the community where the organization is inserted.

Therefore, a crucial point is the company’s ability to make the right choices where the relationship between cost and benefits is as large as possible. For this reason, the decisions cannot be policies or based on personal motivations, but on techniques in the choice of projects with well-defined criteria in relation to the possible alternatives.

However, it is not enough to just select the projects, but it is also necessary to reach a correct priority of action. This prioritization will bring efficiency and effectiveness to the organization and reduce its risks, whether it is public or private.
This paper seeks to compare, by means of the case study, the decision-making process performed in an arbitrary manner and under the technical aspect, analyzing a federal educational institution within the framework of civil engineering projects, showing the differences among them.

The objective is to check if the prioritization of civil engineering projects can reach a gain by using a multi-criteria analysis when prioritizing projects.

This work is justified due to the necessity of public management needing to be efficient and effective in carrying out its projects. With the correct prioritization of decisions, it will be possible to meet the economic and expediting principles governing the public administration, and this way fulfilling the desires of the community it serves.

**METHODOLOGY**

This stage had as its main objective the literature review for providing the theoretical support necessary for writing the article.

The literature review was divided into two areas: First: a study on project management; second: multi-criteria analysis, where the method chosen was the AHP multi-criteria analysis since it is widely used and recognized by the academic community for prioritizing alternatives.

In relation to project management, some stages were carried out such as literature review on the subjects and selection of the prioritization criteria.

The works of Vargas (2010) and Kerzner (2011) were the main ones considered.

In relation to the AHP multi-criteria analysis method, the stages were literature review on the theme, creation of criteria and alternatives, judgment of the criteria, and analysis of the results by using the software IPÊ developed by Fluminense Federal University.

In this case, the works of Costa (2004) and Saaty (2000) were the main ones considered. The literature review was performed by means of researches on the sites Scopus, Scielo, CAPES periodicals, and other internet sites, along with books and articles published on the subject.

No difficulty was found in relation to the literature review process because the AHP multi-criteria analysis methodology adopted for writing the paper is well known and accepted in the academic environment.

The application of the case study methodology underwent the following steps:

- Choice of the Case
- Application of the AHP method for prioritizing projects
- Analysis of results

The case chosen refers to prioritizing engineering projects of a federal education institution.
A comparative study of prioritizing projects was prepared as a conclusion of the study.

**LITERATURE REVIEW**

In order to understand the concept involved in this article, it is necessary to present some existing definitions in the literature on project management and AHP multi-criteria analysis.

**PROJECT MANAGEMENT**

The project is an undertaking with a defined objective, a single non-repetitive effort that consumes resources and operates with targets of deadlines, costs, and quality. Furthermore, projects in general are considered exclusive activities in a company with a beginning, middle, and an end, and are intended to achieve a clear and defined purpose. KERZNER (2011), KNUDSON; BITZ (1991), VARGAS (2009).

The leadership in projects is normally exercised by a project manager who is concerned about the cost, deadline, quality, and meeting the objectives. The technical performance and satisfaction of the various people involved in the project must be the manager’s main concern. Project management according to the vision of PMI (2012) involves ten areas of knowledge: Scope, Time, Cost, Quality, Human Resources, Communication, Risk, Interested Parties, Acquisitions, and Integration, besides the processes related to each area.

While managing the project’s needs, the project manager should administer the three main factors, which are cost, deadline, and scope. These three factors have a direct influence on the results of the project, including with regard to quality. A change in any one of these factors will affect another of these factors (KERZNER, 2011).

The project manager is the integrator that interacts with the various areas of the company, with the suppliers, and with the final customer, which means that he is the point in common for all the actors involved directly or not in the project, so as to achieve the targets established.

For Kerzner (2011), the project manager is the key part for the success of the projects. He needs to have and to know how to use a wide range of skills and know how to effectively negotiate solutions for the conflicts that arise between the needs of the projects and of those involved. Figure 1 outlines the key skills of the project manager.
Figure 1: Skills of a project manager Source: Adapted from Kerzner, 2011.

<table>
<thead>
<tr>
<th>Skills of a Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
</tr>
<tr>
<td>Involves the concentration of efforts of a group of people toward a common goal by enabling them to work as a team.</td>
</tr>
<tr>
<td>Staff Development</td>
</tr>
<tr>
<td>This is the process of assisting a group of individuals, joined by a common purpose, to work interdependently among themselves, with the leader, with the external stakeholders, and with the organization.</td>
</tr>
<tr>
<td>Motivation</td>
</tr>
<tr>
<td>Involves the creation of an environment to meet the project's objectives while it offers a maximum satisfaction related to what the people most cherish.</td>
</tr>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>The greatest reason for the success or failure of a project. It enhances the relations among the team members and brings mutual trust.</td>
</tr>
<tr>
<td>Influence</td>
</tr>
<tr>
<td>It is a strategy to divide the power and trust in the interpersonal abilities to cause others to cooperate to reach common objectives.</td>
</tr>
<tr>
<td>The Decision-Making Process</td>
</tr>
<tr>
<td>There are four basic styles normally used for making decisions by project managers: command, consultation, consensus, and random. There are four main factors that affect the decision style: restriction of time, confidence, quality, and acceptance.</td>
</tr>
<tr>
<td>Political and cultural knowledge</td>
</tr>
<tr>
<td>The skillful use of policy and power help the project manager to succeed.</td>
</tr>
<tr>
<td>Negotiation</td>
</tr>
<tr>
<td>It is a strategy of deliberation with the parties about the interests in common or diverging ones in order to build a commitment to reaching an agreement.</td>
</tr>
</tbody>
</table>

AHP MULTI-CRITERIA ANALYSIS

In decision processes, it is necessary to analyze all the stages that involve a certain problem, taking into account the numerous aspects for which the final product of the discussion is satisfactory and has a theoretical basis, although there may be conflicting data in some cases.

The use of multi-criteria analysis aims to support the decision process without the need to establish the solution, the aid of a multi-criteria analysis towards a decision seeks to establish a relation of subjective preference among the alternatives analyzed, although influenced by multiple criteria in this process and by supporting the decision process. SAATY (2000), CARVALHO ET AL. (2011)

The Analytic Hierarchic Process (AHP), also known as the Hierarchical Analysis Method, is one of the main multi-criteria analysis methodologies, being created in the early 1970s by Saaty. The objective of the AHP is to select alternatives for different evaluation criteria and it is based on three principles: structuring in hierarchical levels, determination of priorities, and logical consistency. COSTA (2011).

According to Abreu et al. (2000), this is a simple method and of a wide application.

Criteria
Abreu et al. (2000) defines that the application of the AHP is made in two phases and is used as a support tool for decision-making, which are:

1. Structuring the problem in levels
2. Evaluation through complex problem modeling in a hierarchical structure

The latter can be observed through figure 2 that presents the structure of the decision's goal for the criteria, sub-criteria, and alternatives:

![Figure 2: Structure of the decision's goal for criteria Source: Abreu et al., 2000.](image)

**Judgments**

The AHP method consists in a tool to build a basic structural model for a decision problem, through the organization developed in hierarchies of criteria so as to facilitate dialog between analysts and agents that make decisions possible. MACHADO et al. (2003).

According to Abreu et al. (2000), in the Evaluation phase, after the hierarchization of the problem, a comparison among the criteria is initiated and also between the sub-criteria, if they exist, where the importance of each one of them will be determined via weights.

These weights are determined by Saaty's Fundamental Scale according to Table 2.
1. Equal importance
   Two activities contribute equally toward the objective

3. Small importance of one over the other
   The experience and the judgment favor slightly one activity over the other

5. Large or Essential Importance
   The experience and the judgment favor strongly one activity over the other

7. Very large or demonstrable importance
   An activity is very strongly favored in relation to the other; its dominance is demonstrated in practice

9. Absolute Importance
   The evidence favors an activity in relation to the other with the highest degree of certainty

2, 4, 6, 8. Intermediate Values
   When a condition of commitment is necessary.

**Figure 3: Saaty's Fundamental Scale**
Source: Adapted from Saaty (2000)

**Analysis of Consistency**

Once the weights and importance of the criteria are checked, the judgements are analyzed and calculated by consistency indexes.

If the consistency index is > 0.10, then it is necessary to check the judgments taken so as to make them consistent. The consistency will be obtained when the index's result is less than or equal to 0.10.

**Alternatives**

The overall evaluation of each one of the alternatives is done using the weighted sum method after the relative weights of the criteria are analyzed and the weights of the alternatives checked.

**Presentation of results**

The results of the AHP are presented through priorities that make it possible to check them. It should be evaluated which of them is superior to the other elements evaluated. The consistency analysis assists in these judgements and makes it possible to evaluate the level of importance. COSTA (2011)

Some of the main advantages and disadvantages of using the method are listed in figure 4.
ADVANTAGES | DISADVANTAGES
--- | ---
Its application may occur in several stages of the processes applied to the method. | Complexity of the mathematical methods to generate results.
Allows the description of the problem in a realistic manner. | Lack of a tool to enable checking the consistency of the opinion of those making the decisions.
Easy to understand and apply. | Need for comparison in pairs of all the alternatives for all the criteria.
Use of qualitative and quantitative factors. | It does not represent a perfect decision consistency.
Exposure of the importance factors. Support in making decisions. Brings confidence to the validity of the final result. | |

**Figure 4:** Advantages and disadvantages of using the method Source: Adapted from Costa, 2011

**CASE STUDY**

For the case study, a centenary federal educational institution with 14 campuses was considered that had buildings with various structural problems due to the age of the constructions. The study period was January to December, 2014.

The prioritization of the projects did not take into account any technical criterion, but only the decision of the authorizing officer for expenditures, without requesting guidance or suggestions from the interested parties.

The institution had five projects to execute during the year of 2014 that had to be ready for preparing the call for bids by September 2014. This way there would be enough time for hiring and beginning the building projects in 2015.

Due to the decision making, none of the projects had their period of preparation nor their cost estimated. Their prioritization took into consideration only the manager's desires.

As a result, of the five projects, only two were completed successfully. Table 1 below illustrates the projects.
Table 1: Projects completed Source: Author

<table>
<thead>
<tr>
<th>Projects</th>
<th>Estimated Time (months)</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1</td>
<td>5</td>
<td>YES</td>
</tr>
<tr>
<td>Project 2</td>
<td>7</td>
<td>NO</td>
</tr>
<tr>
<td>Project 3</td>
<td>2</td>
<td>NO</td>
</tr>
<tr>
<td>Project 4</td>
<td>6</td>
<td>NO</td>
</tr>
<tr>
<td>Project 5</td>
<td>3</td>
<td>YES</td>
</tr>
</tbody>
</table>

The order of priority set was as follows: Project 5, Project 2, Project 1, Project 3, and Project 4. We can observe that the success was not achieved due to factors of preparation time and cost of executing the building project.

The proposal of this article is to assess the same portfolio of projects from the optics of the AHP multi-criteria analysis and check if the manager's decision as to prioritization was correct.

To do this, the software IPÊ developed by the Fluminense Federal University was used to perform the analysis.

According to the AHP methodology, the criteria to be defined are as follows: Estimated Time, Estimated Cost, Strategic Alignment, and Urgency. Table 2 below explains the criteria and alternatives.

Table 2: Criteria and alternatives Source: Author

<table>
<thead>
<tr>
<th>Projects</th>
<th>Estimated Time (months)</th>
<th>Estimated Cost</th>
<th>Strategic Alignment</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1</td>
<td>5</td>
<td>R$ 150.000,00</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Project 2</td>
<td>7</td>
<td>R$ 450.000,00</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Project 3</td>
<td>2</td>
<td>R$ 230.000,00</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Project 4</td>
<td>6</td>
<td>R$ 550.000,00</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Project 5</td>
<td>3</td>
<td>R$ 80.000,00</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

After using the IPÊ software, the result shown on table 3 below was reached.
According to the criteria established, the order of preparing the projects should start by Projects 3 and 5, which, although they are not aligned with the strategy, are urgent. They would be followed by 2 and 4. Therefore, the lack of information in the decision-making process can cause damages to the organization.

When comparing the results of prioritization, urgent projects and those aligned with the organizational strategy were not initially prioritized and the team's energy was spent on projects that were not so important, causing them not to be executed.

CONCLUSION

As per the proposal initially stated, the main objective of this paper was to compare the decision of prioritizing projects with the decision based on an AHP multi-criteria analysis.

It can be noticed that with basic information and well-defined criteria the prioritization performed in a technical way reached a different conclusion. Technically, projects that have an alignment with the institution's strategy or urgency to be done should have a greater weight and be given more attention by the manager.

This fact, though it was clear at the time of the decision, was forgotten and these projects were discarded. Therefore, the efficiency and effectiveness on the part of the administration were not reached.

The alignment with good practices for project management such as planning the schedule with its estimated deadline and the control of costs and its estimate, assist the management unit, but the inter-relationship of the criteria is what provides confidence in the agile and correct decision.

The multi-criteria analysis reaches its goal in prioritizing projects and using software transforms the analysis into something agile, reliable, and easy to use.

REFERENCES


Critique on the Current Understanding of the Brazilian Federal Accounting Court About the Qualitative Amendment Limit Regarding the Amount of a Public Works Contract

André Uryn¹, Thiago Araújo²


ABSTRACT

Summary: This paper approaches the qualitative unilateral amendment promoted by the Government on the basic design tendered for the execution of a public works contract, under a piecework system for a unitary price, as provided for in the General Law of Public Tenders and Contracts of Brazil (Act no. 8.666/93), after the start of its performance, by virtue of the technical inadequacy resulting from its elements. The purpose is to study the application of a limit of 25% (50% for refurbishing) of the updated initial amount of the agreement as provided for in article 65, paragraphs 1 and 2 of Act no. 8.666/93 for the amendment, by discussing the current position of the Brazilian Federal Accounting Court (TCU)³, ⁴ of strongly restricting it, through three perspectives: (i) nature of the amount limit; (ii) calculation methodology; and (iii) regulation of the public work.

Keywords: Public works contract. Basic design. Qualitative amendment. Amount limit. Regulation.

³Reference to the Federal Accounting Court results from the conclusion that this body is certainly the one with greatest influence on the actions of the contracting Government, promoting actual regulation of the public works agreements, despite its function, as provided for in the institutional organization of the Constitution of the Republic, as controlling body of the Legislative Branch.

⁴This paper is based on federal statutes, since most public works contracts in the country are entered into in whole, or at least in part, with Union’s resources.
I – OVERVIEW ON THE THEME

Throughout the world, the different types of public works contract result from three large families: (i) fixed price; (ii) cost-reimbursement; and (iii) incentive contract. The difference is basically due to the allocation of risks - meaning likely occurring and quantifiable events - and the possibility and limits of amendment.

Broadly speaking, while in the fixed-price agreement the risk pertains to the contracted party, since there is no possibility of increasing the amount, in the reimbursement agreement such risk is undertaken by the contracting party, for the full perspective of such increase. The incentive agreement is a midway, as it is possible to enhance the budget as a result of risk allocation (usually prior to the tender), but in a limited manner.

The types of public works contract existing in the Brazilian legal system, to a certain extent, have adopted characteristics pertaining to the three types. Act no. 8.666/93, in its article 10, sets forth four different performance systems: total price, unitary price, turnkey, and the task. In addition to those, the integrated contracting was introduced by Act no. 12.462/11, providing for the Differentiated Contracting System - RDC, and, as regards Petrobras, Executive Decree no. 2.745/98 should be mentioned.

This paper specifically approaches the piecework for unitary price. This is attributed to the fact that the pieceworks for full and overall price have been much modified by Executive Decree no. 7.983/11, which limited the alteration in 10% and required more complete designs, with minimal chances of modification. As for the integrated contracting, it is an incentive contract, in which the design risk is allocated to the contracted party; thus, typically there are no amendments. As

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5 This classification was taken from Gian Luigi Albano, Giacomo Calzolari, Federico Dini, Elisabetta Lossa, and Giancarlo Spagnolo (2006, p. 86)

6 Besides these models supported by Brazilian legislation, others may be adopted. Article 42 of Act no. 8.666/93 allows for the utilization of contractual forms existing in models adopted by international bodies participating in the funding of the work, such as the IBD and IBRD. These institutions usually have their own guidelines, containing standard clauses; however, at the same time, they may adopt other forms, which have been commonly referred to as “International Construction Contract Law”, as explained by Lukas Klee: The most frequently used international standard forms of construction contracts are the FIDIC, forms, the NEC3, and the ICCmodel, Turnkey Contract for Major Projects. Other respected forms include ENAA, IChemE and Orgalime (Grutters and Fahey, 2013). The German standard VOB and the American standard prepared by AIA are both worth mentioning because of their long tradition and established use in their home jurisdictions (KLEE, 2015, p. 1.107).

7 So defined by article 6, VIII, “a” of Act no. 8.666/93: “when the performance of a work or service is hired upon a certain and full price”.

8 So defined by article 6, VIII, “b” of Act no. 8.666/93: “when the performance of a work or service is hired upon a certain price of specified units”.

9 So defined by article 6, VIII, “e” of Act no. 8.666/93: “when a project is hired in its entity, comprising all the steps of the required works, services and facilities, under the full responsibility of the contracted party up to its delivery to the contracting party under go-live conditions, meeting the technical and legal requirements for its use under structural and operational safety conditions and with the characteristics adequate to the purposes for which it was hired”.

10 The task (article 6, VIII, “d”) is the allocation of manpower to small works upon a certain price, with or without supply of materials. Due to the lack of practical use, it will not be approached in this paper.

11 Pursuant to article 9, paragraph 1, “integrated contracting comprises the preparation and development of basic and executive projects, performance of engineering works and services, assembly, testing performance, pre-operation and all other operations required and sufficient for final delivery of the purpose”.

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for Petrobras, item 7.2, “a” of Executive Decree 2.745/98 allows for the qualitative amendment without limits.

In relation to piecework for unitary price, the legislation in force allows for execution of the public works agreement from an unfinished basic design, sufficient for characterizing what is intended to be hired, but still lacks the definitions required for full performance of the work and that cannot be prepared by its performing party.

This design may undergo unilateral alteration\(^\text{12}\), i.e., solely by will of the Government, whose types are qualitative and quantitative, respectively governed by letters “a” and “b” of item I of article 65 of Act no. 8.666/93:

\(\text{Article 65. The agreements governed by this Law may be amended, with the due justifications, in the following cases:}\)
\(\text{I - unilaterally by the Government:}\)
\(\text{a) whenever there is a modification in the design or specifications, for better technical adequacy to its purposes;}\)
\(\text{b) whenever modification of the contractual amounts is required by virtue of quantitative increase or decrease of its purpose, within the limit as provided for by this Law}\)

Both are formalized by means of amendments execution\(^\text{13}\) and cause, or not, repercussion on the agreement term and/or amount. However, they cannot be unlimited as regards their amount:

\(\text{§ 1 The contracted party is hereby obliged to accept, under the same contractual conditions, increases or decreases coming to be effected in the works, services or purchases, up to twenty-five percent (25%) of the updated initial agreement amount of the agreement and, in the specific cases of building or equipment restoration, up to the limit of fifty percent (50%) for the increases.}\)

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\(\text{12 It is what has been commonly referred to as “extraordinary clause”, originating from the French Administrative Law.}\)

\(\text{13 Execution of amendments is set forth by article 38 coupled with article 60, sole paragraph, both of Act no. 8.666/93, as construed by the TCU in its 2014 Budget Manual: “It is worth emphasizing that the amendment instrument shall be entered into prior to the performance of the altered services, since the oral agreement with the government is null (Act 8.666/93, article 60, sole paragraph) and, obviously, the oral contractual amendments are null and the payments based on such amendments are illegal. Besides, payment of any expense may be affected only when ordered after its regular liquidation, meaning the act of verification of the vested right on the part of the creditor, based on supporting deeds and documents of the corresponding credit (article 62 and 63 or Act 4.320/64), i.e., in the case of public works, based on the agreement and the project for whose performance the company was hired (with its amendments). Thus, the signing of agreements and/or amendment instruments with retroactive date is unacceptable in the existing legal system, since the summary publication of the agreement instrument or its amendments in the official press is an indispensable conditions for its efficacy, and it must be arranged for by the Government up to the fifth business day of the month following that of its signature”. However, execution of the amendments is not always required, according to the news aired in TCU newsletter 256: “The alterations performed in a public work project, with consequential modifications in the amount spreadsheets and any other, as required, must be recorded on amendment instruments, jointly with the technical justifications. However, there is no need for existence of technical justifications or execution of contractual amendments in cases of specific alterations not impacting the amounts, the technical specifications or the sizing of the hired services” (Decision no. 2053/2015).}\)
Again, regarding the engineering design, meaning a temporary and singular effort accomplishing a desired physical and material product (MATTOS, 2010, p. 31) with the contracting of the public work, there are many negative consequences of a deficient basic design. Jessé Torres Pereira Junior, in a preface to the book of Paulo Ernesto Pfeifer Santa Maria, clarifies the severity of the situation:

An insufficient basic design creates doubts for the preparation of the proposals that the bidders should submit in the competition; it hampers the establishment of objective criteria for the review and judgment of documents and proposals; it delays process conduct, while exposing it to challenges and appeals; it obliges corrections, increases and decreases throughout its performance; it increases costs and leaves the Government without parameters for the negotiation of item prices not included in the cost spreadsheets, thus generating what, in the accounting court jargon, is referred to as “spreadsheet game”; it enables opportunities for deviations (PEREIRA JUNIOR, 2011, p. 21).

Over the recent years, movement toward the greater control on of public works planning was strengthened after abuses committed by public managers, and this may be identified in the attempt by the Government to impose the bidding from a virtually complete design, named “executive” - or one very close to it. Thus, it is understood that there would be no mistakes or omissions providing the manager with the possibility of deviations causing damage to the Public Treasury, and the principles supporting the bidding statute would be safeguarded.

This thought is more visible in the Federal Accounting Court and the concern has a reason to exist. A survey prepared by the Court in 2007 recorded 400 large works carried out with federal funds with interrupted performance (Appellate Decision no. 1.188/2007 - Plenary Session), with billions of Reais of losses to the public coffers due to failures in their design. In 2014, the Accounting Court conducted an audit in the highway works of the National Department of Transportation Infrastructure - DNIT, revealing that 134 of them were stopped (Appellate Decision no. 162/2014 – Plenary Session) for the same reason. Another inspection carried out in 2014 in basic sanitation works in 491 contracts amounting to BRL 10 billion, also revealed that 283 of them were delayed, stopped or not yet even started, and 80 also had the same serious design issues (TC 003.997/2014-6 - Fiscobras 2014). Cases in which the basic design are merely fictional and simply do not serve for the purpose intended with the contracting are numerous.

The position of the Federal Accounting Court was consolidated in the direction indicated by two decisions now deemed paradigms.

14 TCU’s decisions are numerous. To wit, the one reported in the Tender and Contract Newsletter no. 239/15: “The approval of an inadequate basic project, with great implications in the costs and performance schedules of the enterprise, acquires a severity level sufficient to warrant the pecuniary penalty to the managers in charge and their disqualification for the exercise of the commission office or trust role within the Federal Government” (Decision no. 915/15, dated 04/22/15).
Firstly, the TCU started to understand that both the qualitative and quantitative amendments\textsuperscript{15} are subject to the limit of 25% (Decision no. 215/99), leaving, however, a restricted possibility for its overcoming:

I) the legal limits apply both to the quantitative and qualitative contractual amendments, as a function of the need to observe the rights of the contracted party and the principle of proportionality;

II) in very exceptional cases of consensus and qualitative contractual amendments, the legal limits may potentially be exceeded, [...] provided that the principles of purpose, reasonableness and proportionality are observed, besides the property rights of the private contracting party, provided that the following premises are met on accrual basis:

I - not causing contractual charges to the Government above those coming from an occasional contractual termination due to reasons of public interest, accrued of the costs for the preparation of a new bidding procedure;

II - not enabling the contractual nonperformance, in view of the level of technical, economic and financial capacity of the contracted party;

III - resulting from supervening facts causing unforeseen or unexpected difficulties at the time of the initial contracting;

IV - not causing transfiguration of the purpose originally hired into another one of a different nature and objective;

V - being required to the full performance of the original agreement purpose, optimization of the performance schedule and anticipation of the resulting social and economic benefits;

VI - showing - in the motivation of the act authorizing the contractual amendments exceeding the legal limits as provided for in letter “a” above - that the consequences of the other alternative (contractual termination, followed by new tender and contracting) cause an unbearable sacrifice to primary public interest (collective interest) to be fulfilled by the work or service, i.e., very serious to this interest; including as regards its urgency and emergency;

Then, while reviewing its precedents and historical positions, TCU decided that article 65, paragraph 2 of Act no. 8.666/93 forbids the compensations between increases and decreases resulting from contractual amendments, which must be calculated in a separate manner (the set of increases and the set of decreases) for the purpose of calculation of the legal limit of 25% (or 50%) of the amendment to the agreement. Here follows an excerpt of Appellate Decision no. 749/10:

“(…) 9.2. determine to the National Department of Transportation Infrastructure that, in future contracting, for the purpose of meeting the contractual amendment limits as provided for in article 65 of Act no.

\textsuperscript{15} At the time, most of the doctrine understood that the amount limit could only be applied to the quantitative amendment, due to the wording difference between the letters of item I of article 65 of Act no. 8.666/93: while, for quantitative amendments, letter “b” expressly states “within the limits as provided for by this law”, the same limiting command is not present for letter “a” as regards the qualitative amendment.
8.666/1993, it starts to consider the decreases or increases of quantities in an isolated manner, i.e., the set of decreases and the set of increases must always be calculated on the original agreement amount, by applying to each of these sets, individually and with no type of compensation between them, the amendment limits set forth in the legal provision”. (italics added).

Besides the Accounting Court, in the National Congress, the main project aiming to amend Act no. 8.666/93 – Senate Bill – PLS no. 559/13 - bears a strong provision in this regard, applying the methodology of algebraic sum 16 for the calculation of the limit, kept as 25%17. Further, another project reducing from 50% to 25% the possibility of variation of contractual amounts for the case of restoration has been recently approved in the Constitution and Justice Commission of the Senate18, from which a first reaction to the recent corruption scandals involving Petrobras can be derived. During investigations of the “operation car wash”, the execution of amendments highly increasing the amounts of the work contracts was found, as broadly disseminated by the press19.

Regarding fulfillment of the project, PLS no. 559/13 determines the tender from an executive design20, in the events of public work contracts whose design is not prepared by the party performing the work, such as those currently provided for by Act no. 8.666/93. The Reporter in the Infrastructure Commission of the Senate, Senator Fernando Bezerra, author of the replacing text – this provision was not present in the original wording of Senator Kátia Abreu-, expressed as follows21:

Among the innovations, there is the provision according to which the engineering services and works may be started only when there is an executive design, in order to favor study and planned action by the Government. With that, we expect to repel the widely disseminated practice of promoting tenders only with the basic design, which may often generate successive amendment instruments with a view to correcting project deficiencies that may be often predictable.

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16 An algebraic sum means that any amendment, whether for increase or decrease, will be considered for the calculation of the 25% limit. Thus, in the event of an amendment increasing the agreement by 20%, only new changes totaling 5% of the updated agreement amount may be promoted in any regard. This methodology apparently is even more restricted than TCU’s guidance as provided for in Decision no. 749/10, separately assessing the 25% limit for the set of increases and the set of decreases.

17 Article 105. The 50% limit for restoration was kept.


20 This is the provision of paragraph 5 of article 39: “Except for event as provided for in item V of the caput of this article, the tenders may only be executed when there is an executive project approved by the relevant authority, available for review by the parties interested in participating in the bidding process, as well as relevant licenses, authorizations, and expropriations”. It is worth mentioning that this is the final text approved on 12/02/2015 and that goes to the Plenary Session.

21 Amendment no. 12, authored by Senator Romero Jucá, was the first in this regard; however, it did not prohibit the conduction of tender from a basic project, but rather the start of the work without the executive project. Available at <http://legis.senado.leg.br/matweb/arquivos/mate-pdf/n84306.pdf>. Accessed on December 24, 2015.
The general understanding is that the restriction to contractual amendments serves as an instrument to avoid the enormous losses caused to all the levels of the Government. In the current scenario, the amendments would be the major villains responsible for wastage existing in the Brazilian public works, and should be abbreviated at all costs, by imposing a limit of such a low amount that would induce a greater planning of the work, especially in a better and more complete basic project, free of losses from amendment.

However, it is necessary to assess the consequences of this maximalist remedy and whether there is an actual benefit in the legislative trend and TCU’s recent understanding, or whether the current movement, defending a restriction that has never been seen in the Brazilian legislation by virtually eliminating the work piece for unit price and the basic project, merits to be challenged, in order to be at least shaped, not only based on the Law, but essentially on economic and technical criteria.

The public works agreements, mainly those intended for infrastructure implementation, are complex and naturally do not provide for all the range of events that may occur after their execution. Besides, the costs - of different types - for search of the information required for the design preparation indicate that, it is often more efficient to leave certain solution to the performance phase. It is what economic theory calls “incomplete contracts”.

Two paradigmatic decisions of the Federal Accounting Court resulted from omissions of Act no. 8.666/93, whose wording fails to refer to critical questions for performance, such as project error, the hypothesis of supervening finding of unpredictable work factors and methodology for the calculation of the 25%. And maybe the most important thing: since the law indistinguishably approaches purposeful lack of information existing in the tendered project and wrongful preparation, the appellate decisions of the Court usually mix up both the circumstances, which in fact are not to be confused and should not receive the same treatment, since they deal with different risk types.

The theme about the system of amendments to public works agreements is not new and has been already intensively discussed soon after Act no. 8.666/93 was issued. However, in light of the idea that the amendments are connected to the planning of public works, it merits to be revisited, not with a view to enabling the preparation of a loss-causing project, but rather toward better programming of the state actions.

II – NATURE OF AMOUNT LIMIT

In addition to the general principles guiding the actions of the Government, the Federal Accounting Court directs its concern specifically to the rule of the tender and the principles supporting it, such as binding to the calling instrument and impartiality. This is because the alteration of the tendered...
purpose, according to the understanding of the Court, would result in a kind of direct contracting without legislation support. The result would be the lack of competition, with a strong loss to the cost-effectiveness.

However, the law did not provide for a test or formula for checking contractual purpose modification. Obviously, in some cases, ascertaining may be performed by employing common sense. For example: in contracts whose purpose is procurement of a good, let us say, a covenant aiming at the purchase of ten Fuscas, this may not be converted into the purchase of ten Monzas. Nevertheless, regarding a complex contract, such as for works, this analysis is not simple. A highway work of great linear extension, for example, has hundreds of items in its composition. Then, how to control the limits of its amendment? Therefore, the Federal Accounting Court has sought a formula enabling the objective ascertaining of the change to the tendered purpose.

Until the pronouncement of Decision no. 749/2010, administrative practice usually accepted by TCU was that of removing a certain item from the contracted spreadsheet, while promoting its replacement. Thus, it was fully possible to perform compensation of a decrease with an increase, so that contractual amount did not truly reflect the alterations promoted. The Court decided to seek in the 25% amount limit a way to curb amendments, so as to ensure a greater inviolability of the tendered purpose. Then, the checking of the limitation started to be carried out through a separate set of increases and decreases. Please see the excerpt of Decision no. 749/10 (vote of Reporting Minister Walton Alencar) substantiating the measure:

Incidentally, occasional adjustments and amendments do not always presume, by themselves, significant changes to the original agreement purpose. These adjustments do exist and are sound, provided that the compatibility of these changes with the essential qualitative and quantitative aspects as defined in the basic design is complied with, as defined in article 6, item IX, of Act no. 8.666/1993, and the limits set forth in article 65, paragraph 1 of said statute are observed.

Therefore, TCU started to expressly bind the amount limit to maintenance of the purpose in order to safeguard the bidding rule and the principles supporting it. However, we do not agree with this understanding.

Contractual purpose should be seen as a set of factors formed by the Government’s intention to implement a specific utility, analyzing the nature of the good, its specifications, qualities, quantities, contractual term and other concrete characteristics making a work singular. This would be the correct manner of defending the principle of binding to the calling instrument.

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23 To wit, an excerpt of Decision 749/10: “Further, another relevant topic in this process is the high percentage of amendments produced in the originally tendered purpose, above 100%. Consistently with what is reported by the instruction, the original purpose summarily underwent a 49.4% decrease followed by an increase of new services amounting to 135.2% over the remaining balance (or almost 70% over the original arrangement amount). With that, in practice, the work that was actually performed had only 42% of its extent actually tendered. The remaining 58%—so called “new services”—were contemplated by direct contracting, without public tender, in clear breach of the Constitution and the Law”.

24 It is certain that, since the mentioned decision 215/99, this has already been made by limiting the technical adjustment amendment by the amount, but the compensation was allowed.

25 This is the understanding of Petrobras Contracting Procedure Manual, which serves as a sort of regulation and integration of Executive Order no. 2.745/98. Please see items 2.1.34 and 5.2.13: “2.1.34 - Scope: aspects pertaining to the contractual purpose, such as
Generalization of the 25% limit conceals this basic condition of engineering, which may be suffering beyond measure with legal concepts, as warned by Luiz Freire de Carvalho e Mário Sérgio Pini:

The legal impositions have brought a perverse effect with them: the eagerness of classifying the reality of the works into tabled standards. Thus, it is not a surprise that standard rates for the BDI [indirect benefits and expenses], which is the builder’s fingerprint, for the Social Charges, containing several adjustment factors, and so on, for Site, Local Administration and other cost variables of singular essence perfectly subject to budgeting are sought. The principles of Cost Engineering do not allow for reduced treatments, with the resort to percentages, supposedly applicable to all the works. Standardization is a gateway of numerous analysis and assessment distortions, replacing the application of Engineering knowledge, and making room for action by non-specialized professionals [...] The study of any object is more comfortable based on standards, but this transfer to the engineering will cause its succumbing. The standards simply ignore logical reasoning, calculation and the demonstration with knowledge, which is discouraging the development of Construction” (CARVALHO; PINI, 2012, p. xxii-xxiii).

This would be the way for harmonizing the possibility, as provided for in article 9 of Act no. 8.666/93, for the work to be tendered with a basic design. Then, for what purpose would the 25% (50%) amount limit would serve? We think that the answer lies in (i) contractual governance; and (ii) in the public budget.

(i) Contractual governance

Intricate social progress and the growing need for the use of agreement as a way to enable exchange and circulation of wealth, which might even bulge over time, have generated a higher complexity of the contractual purpose and of the instrument itself, making it unfeasible for the wealth-maximizing economic person to predict and even apprehend the consequences of all of the cases involved in the obligation undertaken by the parties, which has been commonly referred to as limited rationality.

Then, it began to be understood that the contracts, as a general rule, are incomplete, whether because the costs for obtaining all the information required for its writing would render the business itself unfeasible, or due to its simple material impossibility as regards all of the events which might impact the performance of the covenant.

specifications, place and methodology”; “5.2.13 - The Agreements may undergo amendments in the Scope, provided that they do not cause an amendment to its performance purpose”. In this regard, this is the opinion of Floriano de Azevedo Marques: “It is clear that the quantities and the list of services required for the performance of the hired work do not integrate its purpose. In this sense, we have already stated on another occasion: ‘Thus, when the government hires the construction of a school from a private party, it is thereby entering into an agreement with the purpose of acquiring a building, with specified characteristics and quantities sufficient for its use as a teaching facility, that is, for the purpose pertaining to it. It is so, because understanding as the purpose of an administrative contract not only the intended qualities thereof (construction of one- or more-school(s), restoration of a specific public building, construction of a building in the x section of river y, etc.) but also all of the technical specifications and quantities accompanying it, would evoke the impossibility of exercising the jus variandi pursuant to the provisions of the new law, in its article 65, I, a.” (MARQUES NETO, 1998, 103-119).

26 The doctrine usually approaches the theory of incomplete contracts directed to related, long-standing contracts, such as public service concessions, but nothing prevents it from also being applied to the public works agreement, due to project complexity.
Thus, in light of the typically small perspective of occurrence of all of the events that should be listed in contractual wording, in certain cases it would not be worth preparing a full agreement, due to the cost – including of opportunity – for appropriation of all this information. This hypothesis becomes increasingly clearer as regards large public works agreements aimed at the implementation of infrastructure.

However, the execution of an agreement not containing all the information also generates costs27, since it leaves margin for one of the parties to better know the purpose and the way of performing it as compared to the other. This asymmetry of information may enable an opportunistic, i.e., non-cooperative, behavior, as the rational agent acts so as to maximize its earnings in a scenario of antagonist interests. The implications usually identified by Economics, especially the Agency Theory28, are the moral hazard, adverse selection and hold-up29.

Thus, economists have thought about incentive mechanisms that could lead to an efficient fulfillment of a contract. Two theories may be mentioned, now deemed complementary, that addressed such difficult questions pertaining to contractual incompleteness, limited rationality and information asymmetry, seeking to overcome them by means of new arrangements and contractual models.

One of the economic theories better explaining this situation was developed by Oliver Williamson, called Transaction Cost Economics - TCE, originated from the analysis conducted by Ronald Coase on the economic role of the company. Its initial proposal comprises the organization as a vertical integration, that is, provided that it is possible, the production phases or chains should be concentrated in a single company. The higher the transaction cost, the deeper and more comprehensive the intervention would be.

Later, in a classical study on the theme, Sanford Grossman and Oliver Hart criticized Williamson, who, according to them, had only helped to demonstrate that the costs for the purchase of goods by differ-

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27 Fernando Araújo explains that: “In our opinion, the main source of inefficiencies in transactions is asymmetrical distribution of information between the parties involved in the exchanges - an asymmetry almost fully explained and justified by the initial economic decision of which the exchanges are the ultimate consequence - the decision of specializing production, dividing work and concomitantly dividing information. When it comes to the time of the exchanges, however, it is necessary to recover some information, and this causes costs: costs related to information on prices and quality of products and production factors, on potential buyers and sellers, on willingness to pay and accept prices; ex ante and ex post dealing and motorization costs of the other party; costs of compliance and reaction to noncompliance; costs of protection of agreement relativity before the risks of damaging interference by third parties.” (ARAÚJO, 2007, p. 199-200).

28 In the Agent-Principal model, the principal delegates a task to the agent, which has a certain informational advantage, but it has no means or knowledge for verifying the level of commitment employed for the attainment of the expected result. Since there are antagonist interests and the rational trend of maximizing the results, the agent will tend to act in a line not supporting the principal’s desires. Therefore, mechanisms realigning actions are required. In the administrative agreement, the Government acts in behalf of the society, while the private party aims at its personal profit interest. Jean Tirole, winner of the 2014 Nobel Prize in Economics, together with Jean-Jacques Laffont, scientifically demonstrated this definition applied to regulation: “The regulator observes the costs of the production performed, but not the efforts in cost decrease (hidden issue of post-contractual effort). Further, the company knows more about its cost-reducing mechanisms than the regulator (hidden issue of pre-contractual information)” Available at: <http://www.ecgi.org/documents/sciback_ek_en_14.pdf>. Accessed on: January 09, 2016.

29 As taught by Rachel Sztajn, “Having information regarding the goods, property and assets of the other party is a fundamental condition to facilitate agreement fulfillment. Since, in general, obtaining information has a cost, and since people are not always willing to make the investment required to obtain it, the difficulty of entering into balanced agreements from the start is clear. Measuring information is often complicated and there are cases in which information is difficult to be obtained, requiring additional activities by the parties. When one of them is aware of something that is not known to the other, it is said that information is asymmetrical, and the issues in the preparation of agreements arise from this: the adverse selection and moral hazard (SZTAJN, 2006, p. 171).
ent companies may be increased. For the authors, there are two problems in the TCE. One of them would be company size, since the purchase of others would bring costs. The other would be the lack of explanation on the reason why the integration would change the opportunistic behavior of a supplier coming to the employed by the company acquiring it (GROSSMAN; HART, 1986, p. 692).

The authors divide contractual rights into two: specific, i.e., those originally written in the agreement, and residual, i.e., emerging after the start of the performance. According to them, “We assume that the integration itself does not change the cost of writing a particular contractual clause. What changes is the party holding the control over these provisions not included in the agreement” (GROSSMAN; HART, 1986, p. 695). The work of Grossman and Hart casts some light on the question of renegotiation, showing the efficiency, based on economic logic, of a contractual arrangement setting forth post-contractual rights, while distributing them, with the purpose of overcoming transaction costs.

Both theories, that of Williamson regarding integration (form of organization) as an instrument for overcoming transaction costs and that of Grossman and Hart, on the possibility of renegotiation of post-contractual (residual) rights, may be classified into the different existing contractual arrangements of public works.

The agreement has become, with an increasing strength, an instrument of economic regulation, since it enables an opportunity for allocating risks between the parties involved in the business. This is the most efficient solution found for the contractual incompleteness.

Thus, the incentive agreements, such as the Brazilian integrated contracting, have shown to be superior for addressing transaction costs. Under this circumstance, Williamson’s theory is applied in the understanding that the design is prepared and performed by the same contracted party, and the risks, as taught by Grossman and Hart, may be allocated to this party, even if in a burdensome manner. It is worth noting that, in the integrated contracting, as a general rule, there are no amendments, except for very extraordinary cases, and the contracted party undertakes the risks of the design prepared by it.

Overcoming of problems usually resulting from the incompleteness may be promoted by means of an efficient contractual design, in which the contracted party has incentives to address the risks. Meanwhile, as explained, the traditional public works agreement was not molded so as to make this possibility feasible: the design, as explained, is not prepared by its performing party; besides, we understand that the preparation of a risk matrix for its relocation, from the contracting Government to the contracted party, is not possible.

Therefore, the traditional public works contract must coexist with a system of cooperative gov-

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30 This situation arises from two legal factors and one practical. (i) Law No. 8,666 / 93 doesn’t regulate the possibility of drafting risk matrix. However, it also does not allow the risk allocation to the contractor through the payment of a contingency fee, as the margin of acceptability of the bidder’s proposal is given in relation specifically to the price, which consists of direct and indirect costs (art. 40 X). (ii) In addition, as discussed in public works contract regulated by Law No. 8,666 / 93, the basic design is prepared by hired distinguished than whose perform the work. In this scenario, the risk matrix is not attractive because the contract for the work will have to venture to take on a project that did not worked out. (iii) Finally, the Administration, even if today wanted to, could not develop risk matrix. Public managers have not been trained for such a sophisticated system and do not know the methods to do so. A long period of learning and real generational change is necessary to implemented the risk culture.
ernance between the parties dealing with safeguards in order to limit or even suppress opportunistic behaviors, such as the provision of sanctions, robust inspection and amount limit for the contractual amendments, the latter representing a true clause for the automatic termination of the agreement, as if it were a condition, if exceeded. Therefore, in this topic, we agree with the guidance consolidated in the TCU, that the qualitative amendments must also be subject to an objective amount limit.

It can be concluded, in light of the economic theory of incomplete contracts, that:

1 - The identity of the tendered purpose is not directly linked to amount of the contractual items occasionally increased or decreased, as indicated by the economic theory. With the increasingly higher complexity of the agreements, price is no longer the only reference of information. The contract amount itself does not convey the knowledge required for fulfilling it or fully characterizing it. Unlike the purchase of a magazine at a newsstand, price alone does not reflect the contractual purpose and, therefore, it may not serve as mechanism for the control of its alteration without investigating other factors. As explained by José Vicente Santos de Mendonça:

Price systems are good to convey information such as “there was a record grape harvest in southern Brazil”, but are unable to convey information such as “how the traditional Frombrauge vineyard wine is produced’ (MENDONÇA, 2014, p. 416).

2 – Price serves as an incentive mechanism, within a larger set aiming to overcome governance issues - approached by the agency theory - in the public works agreement. In this line of thought, the upper limit of 25% (50%) also serves, like in the hypothesis of global price, as a form of incentive for the prices of new items to be even reduced, in other words, as a form of bargaining by the Government. The contracted party, under certain conditions, will have to choose between decreasing the price and terminating the agreement.31

(ii) Financial question

When analyzing the legal provision approaching the amount change limitation, it is possible to notice that, in such provision, the legislator intended to prevent (i) that the total agreement amount was increased so as to cause an unplanned expense by the Government and a gain much higher than the one originally proposed by the contracting to the contracted party, thus breaching the principle of legal equality – but without relationship with the tendered purpose amendment, but rather due to a financial question; and (ii) that this same contracted party was damaged by the remarkable decrease of its contractual performance, except for the case of an agreement by and between the parties. Therefore, it is a clause concerning the total amount of the covenant, aiming at a relationship between earnings and expenses, not relating to the amendment of the hired purpose.

In this regard, please note that item II allows for an amendment at an amount above 25%, in case of agreement:

31 It is obvious that TCU’s restrictive methodology - preventing compensations - strengthens this aspect. But our intention is to demonstrate that the amount limit is related to financial questions and not immediately to the tendered purpose.
Paragraph 2 No increase or decrease may exceed the limits as provided for in the previous paragraph, except for:
I - (VETOED)
II - the decreases resulting from agreement entered into by and between the contracting parties.

Then, in case of mutual consent, the 25% limit applies solely and exclusively to the increases, and not the decreases, according to the provisions set forth in paragraph 2. But a question remains: is the ultimate purpose of article 65 as a whole is – as claimed by TCU – the tendered contractual purpose preservation, why allowing unlimited decrease? In virtue of an agreement by the parties only? May the latter amend, to its discretion, the contractual purpose, excluding items at will, without any limitation?32

In summary, the of the legal text analysis shows that the purpose of article 65 is limiting in nature. But not in relation to the contractual purpose, but rather with some maintenance of the economic and financial balance33 of the settlement executed by and between the Government and the private party, when such balance, in whatever way, is compromised by reasons inherent to contractual relationships, i.e., contractual amendments.

The Law clearly allows for contractual amendments, including those of unilateral nature, but requires that they be performed with caution and attention, so as to avoid excessive earnings or losses by either party.

In this line of thought, the nature of the limitation is also clearly budgetary and financial – article 65 provided for, in all of its items and paragraphs, the potential effects of a nature regarding the expense of amounts that may be borne by the parties, in case of contractual amendments34. This is the core,

32 Further, the reason supporting protection of the tendered purpose must be attained. Modifying it would theoretically cause the devoiding of the competition existing in the bidding and make the obtainment of the most advantageous proposal for the Government unfeasible. The legal possibility must be contemplated by two “axioms” coming from Economics: (i) the less complex/bulky or even lower-scale the good or service to be hired, the larger the number of players in the market that are able to fulfill it - that is, able to become qualified in a public tender; and (ii) the larger the number of qualified parties in a public tender, in case of a normal competition scenario, the lower the price must be to be paid by Treasury. Thus, ending the ad absurdum reasoning, if the provision in question served for contractual purpose modification control, in order to keep the advantage enjoyed by the Government by means of the public tender, it would only work in increase cases, but would be innocuous in decrease cases. This is because, and the argument is ended: let us imagine that the Government opens a public tender for a very complex project requiring technical qualification consistent with the technical difficulties. In this scenario, a few interested parties would compete, thus diminishing the potential discount to be obtained by the Government. However, proceeding with the line of thinking, during performance of the agreement, the decrease of the purpose is allowed. And here is the most relevant aspect: the remaining items and services could have been theoretically hired at a lower price, since if they were tendered on a separate basis, they would demand a lower technical requirement and, consequently, they could be competed by more private parties, which would cause the obtainment of a greater discount. For this reason, in case the contractual amount is an actual parameter for the agreement amendment limit, the estimation about the possibility of decrease of a volume higher than 25% would be unreasonable.

33 The economic and financial balance referred to herein is not that which determines maintenance of the original conditions of the contracting, but rather the one which tends to avoid, in light of the need for changing those initial circumstances - without transfiguring the purpose - an excessive gain or loss to the contracting party or the contractor.

34 The only exception in the topic, in our opinion, is letter “d” of item II of article 65, which, so to speak, addresses economic and financial imbalance when coming from factors external to the agreement (supervening factors) and which, therefore, must not be subject to this amount limit.
the nucleus of the question: the legislator, in article 65, aimed to protect the contracting parties from the sudden and disproportionate financial effects arising from contractual amendments. This is the reason behind the setting of the 25 and 50% rates: the legislator assumed that, while observing these percentages, the financial effects of the increases and decreases will not be so great as to generate excessive financial gains or losses to the parties. It is worth keeping in mind that the resources of the State are finite and that their management depends on planning and a series of laws imposing limits to the public expenses, such as, in the Brazilian case, the Multiannual Plan (PPA), Budgetary Guidelines Law (LDO) and Annual Budgetary Law (LOA), in addition to Act no. 4.320/64 and Fiscal Responsibility Law (Complementary Act no. 101/00).

Therefore, in light of the analysis regarding the recent position of TCU, it is important to set the premise that the 25% (50%) limit is not intended for establishing a frontier between changes of items preserving the contractual purpose and those distorting it; in fact, maintenance of the contractual purpose must be checked in any and all changes of items, regardless of their percentage impact on the overall business amount.

Therefore, we do not agree with the statement that exceeding the 25% (50%) limit presumes significant transfiguration of the tendered purpose, causing a new direct hiring without support from the legislation.

III – METHODOLOGY EMPLOYED BY TCU

In addition to the incorrect use of the 25% (50%) limit as sole parameter for the preservation of the tendered and hired purpose, we think that the methodology employed, prohibiting the compensation between the set of increases and decreases, is not supported by the text of the law. Please note that the provisions addressing the amendment limits are clear. Paragraph 1 of article 65 of Act no. 8.666/93 sets forth that the contracted party is obliged to accept a total of 25% (50%) increase in the agreement amount – it is an extraordinary clause already studied. Please see its wording: “paragraph 1 The contracted party is hereby obliged to accept, under the same contractual conditions, the increases or decreases coming to be necessary in the works, services or purchases, up to twenty-five percent (25%) the updated initial amount of the agreement, and, in the particular case of building or equipment restoration, up to the limit of fifty percent (50%) for its increases”. It is important

35 André Mendes, already predicting the numerous problems that the new methodology for the calculation of the 25% limit of the agreement would cause, understands that its overcoming is possible based on three requirements: “Imagine the budget for the construction of a highway stretch anticipating large volumes of earth moving, brought from a excavating area located 10 km away. Let us suppose that, upon the start of the work, the permit for exploiting the compatible material from another field located only 5 km away is obtained. In case the exclusion of the item regarding the 10 km distance and inclusion of another, corresponding to the 5 km distance, represents an increase above 25%, the automatic and inflexible application of the jurisprudence now being discussed would prevent this change, even if it would mean a decrease in the final amount of the work. In cases like this, one must appeal to common sense and flexibilize this understanding, provided that it is aligned with the public interest. If a careful assessment of the concrete case indicates that: a) there is in fact no purpose amendment, since the services included and excluded are of the same nature and are performed with the same inputs, and the transportation distance difference is the only distinction between them; therefore, there is no cause for treating it as a breach of the principle of equality; b) the contracted party is not obtaining any extra advantage from the modification, since its prices for both services have the same proportion in relation of the reference amount considered; c) the change is advantageous to the Government, since the final amount of the work will be decreased and the final product will the exactly the same (MENDES, 2013, p. 217).
to verify that the legislator used the plural of the alterations, that is, he wanted all of these alterations, which may not result in an amount above 25% (or 50%), to be considered in the account. Unless the contracted party so agrees – it could not be forced – so that the amounts above this limit incorporated into the agreement would be the result of a bilateral alteration and no longer unilateral, resulting from the extraordinary clause. Now, obviously, the total amount of 25% can only be found with calculation of the compensation between increases and decreases, since the contrary understanding would lead to the absurd procedure of creation of two different amounts for the administrative agreements: the consolidated amounts coming from the increase along with the consolidated amounts from decrease, which would be at least unreasonable and pointless.

As for paragraph 2 of article 65, Act no. 8.666/93 - which in this case, no longer addresses the unilateralism issue, but rather the limit itself - uses language in the singular: “paragraph 2 No increase or decrease may exceed the limits as provided for in the previous paragraph, except for (...)”. In other words, in every increase or decrease, the 25% (50%) limit must be assessed. Therefore, here, the methodology is of another kind. The wording of this latter (article 65, paragraph 2 of Act no. 8.666/93) has no relationship with the outcome as provided for in the Appellate Decision no. 749/10, referring to the set of increases and decreases. It is worth keeping in mind that the TCU considers the limit as the total increases of 25% on one side and the total decreases of 25% on the other. When observing this set on a separate basis, it understood that there could be no compensation. However, with the due respect, this is not the letter of the law, nor, as seen, its teleology. This seems to be the methodology existing in the recent Directive no. 24/2014 of the European Union.

So that what the above becomes clearer, we show below the four methodologies created up to now and studied for the application of the 25% (50%) amount limit:

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<td>Meaning of paragraph 1 of article 65 of Act no. 8.666/93 – aimed at the extraordinary clause of the law</td>
</tr>
<tr>
<td>(ii) The amendments must be verified in sets of increases and decreases that cannot be compensated, and each of these limits may not exceed the 25% (50%) limit</td>
<td>Appellate Decision no. 749/10 TCU – Plenary Session</td>
<td>We did not identify this provision in Act no. 8.666/93</td>
</tr>
<tr>
<td>(iii) The amendments, whether increases or decreases, are always summed up in a single account</td>
<td>Senate Bill no. 559/13</td>
<td>There is none at the time; under discussion phase in legislative process</td>
</tr>
<tr>
<td>(iv) Each amendment individually incurs the incidence of the 25% control</td>
<td>Provision of article 72 of Directive no. 2014/24 of the European Union for non-substantial amendments</td>
<td>We consider that this is the meaning of paragraph 2 of article 65 of Act no. 8.666/93 regarding the calculation of the percentage limit</td>
</tr>
</tbody>
</table>

In summary, we understand that item (i) above is the one adequately reflecting the meaning of paragraph 1 of article 65 of Act no. 8.666/93 and item (iv) that of paragraph 2 of article 65 of Act no. 8.666/93, and the constructions (ii) and (iii) must be repelled, since they are not supported by the letter of the Law nor by a final construction of the statute.
IV – REGULATION OF PUBLIC WORKS AGREEMENTS

The theme of public works in Brazil merits an extensive and detailed legislative treatment. Laws issued and approved by the Legislative Branch, and sanctioned and enacted by the Executive Branch, propose to provide for the conception, selection, contracting and performance of the most varied work pieces that, in one way or another, involve the Government.

It would be proper to suppose that, in this case, the applicable laws - from Act no. 8.666/1993 to Act no. 12.462/2011, instituting the RDC - would bring a set of rules and provisions governing over the matter in the widest and most detailed way possible, providing for situations with which the several agents involved - especially the Government and the contracted private parties – would have to deal in project development and performance of the contract design and in the daily routine of the fields.

However, this supposition is chimerical. It is a common experience that even the best prepared law, most carefully created by the most dedicated specialists, is unable to predict all the situations, all the hypotheses that its long-standing application to the facts of life may trigger.

In the case of public works, the laws are negligent regarding the matters of agreement performance, while mostly regulating public tenders only. Act no. 8.666/93 fails to establish how a design taken to public tender should be prepared, only defining minimum elements that must be included in such document and determining that its amendment may reach the limit of 25% (or 50% for increases in case of building or equipment restoration). The law only provides for parameters to abide by, but without further specifications. In precise words, the basic design is a sum of concepts requiring technical, legal and economic knowledge, together with political resolutions, to be made concrete.

The decision about these elements must come from the Executive Branch, which, after all is the contracting party legitimated to, within the margin set forth by the Legislative Branch, define the best way of designing the strategy to be used for the design preparation and performance of the work. The completion level of the design and its consequential alteration depend on the understanding about the legal, social and economic effects of the work and its costs, in other words, it is systemic and surpasses the agreement clauses.

This regulation function of Act no. 8.666/93 regarding the basic design and its amendments has not been duly exercised, giving margin to control bodies, remarkably the TCU, to establish rules which, with the due respect, are out of the scope of its constitutional duty as control bodies.

TCU decided, in TC 002.089/2012, that Instituto Brasileiro de Obras Públicas, consisting of members of the Accounting Courts, could regulate article 6 of Act no. 8.666/93. This institute, private in nature, issued OT IBR 01/2006 (mentioned in the second chapter). Please see the excerpt of Appellate Decision 632/2012:

9.1. determine Segecex to make the units subject to court jurisdiction aware that the guidance as provided for in OT IBR 01/2006, issued by Instituto Brasileiro de Auditoria de Obras Públicas (IBRAOP), will start being complied with by this Court in the inspection of public works.
CONFEA has also recently adhered to this definition through Normative Decision no. 106/2015. ABNT is adopting the same conduct, by means of the Special Study Commission CEE-162. TCU’s guidance of TCU is also being applied by accounting courts of other federative levels.

Despite the noble intention of preventing the occurrence of loss to the Treasury, there is no legal delegation allowing for the regulation of the theme by IBRAOP, which would be, in case such delegation existed, an assumption of non-state public regulation. The absence of legal command in this regard prevents the mandatory rule of the compliance with said technical guidance by third parties, in light of the breaching of the principle of legality, a corollary of the very notion of Rule of Law. Alexandre Aragão teaches:

Regulation by the market and self-regulation rules coming from private entities or companies (corporate rules and regulations, association decisions, private codes of conduct etc.) must be excluded from the concept of regulation itself, except if coming from Government delegation, in which case we will be dealing with non-state public regulation, through which the social entities, usually concerning a specific professional collectivity (among us, for example, the professional councils and sports entities), undertake, within their scope, the role of regulation, without, however, being transformed into State bodies, which, however, grants them its authority through the legislative or constitution route (verbi gratia, article 207 and 217, I, Federal Constitution).

In fact, in the absence of a legal delegation, at most, IBRAOP rulings would constitute a self-regulation hypothesis, but would not have binding effects upon third-parties not associated with the Institute. Thus, there is no way for the TCU to impose compliance with the above technical guidance by the Government.

In Brazil, up to the emergence of Constitutional Amendment no. 32/01, the Government could only issue executive orders with the purpose of faithful compliance with the law, by detailing its commands without extrapolating them, pursuant to article 84, IV, of the Constitution of the Republic. It is the classical regulatory power.

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36 It is worth mentioning that Act no. 4.150/62 provides for the following: “Article 1 In the public services granted by the Federal Government, as well as those of state and municipal nature subsidized or performed by it in convention system, in the works and services performed, directed or inspected by any federal departments or parastatal bodies, in all the purchases of materials made by them, as well as in the corresponding competition announcements, settlements and price requests, the requirement and application of the minimum requisites of quality, utility, resistance and safety usually called ‘technical standards’ and prepared by the Brazilian Association of Technical Standards, referred to herein as its acronym ‘ABNT’, will be mandatory”. We understand that ABNT would not be liable for resolving upon how the Government may plan its contracts, but only on the requirements of the executive project, as provided for in the law, since it is a technical matter.

37 In the State of Rio de Janeiro, there is news of at least one precedent, in process 101.790-0/15, addressing the audit on the infrastructure and pavement works promoted by the State in the Municipality of Duque de Caxias.

38 Gustavo Binenbojm (2014, p. 165) notes that the notion according to which regulation may not innovate in the legal system must be approached with caution: “The use, increasingly more frequent, of undetermined legal concepts of broad semantic spectrum strongly expands the scope of the regulatory power. Doctrine and jurisprudence tend to proceed towards a wide concept of performance regulations. In this regard, Caio Tácito explains that “regulating is not only analytically reproducing the law, but expanding and completing it, according to its spirit and content, mainly in the aspects in which the law itself, expressly or implicitly, grants authority to the regulatory level”.
With the emergence of Constitutional Amendment no. 32/01, amending article 84, VI, “a” of the Constitution of the Republic, the Brazilian legal system started to include, besides performance regulation, the autonomous regulation\(^\text{39}\), which may be considered as a new source of law, directly emanating from the Constitution\(^\text{40}\). Pursuant to such provision, the President of the Republic has the duty of providing for, upon executive order, the organization and operation of the federal administration, when it does not mean an increase in expense or creation or extinction of public bodies.

From a modern point of view, regulation was strengthened with the perception that the State could not fund all society demands society. This notion culminated in the consensus of a “new governance model including the privatization of many parts of the public sector, more competitiveness throughout the economy, greater emphasis on the economy on the side of the offer and far-reaching reforms in the welfare State” (MAJONE, 2014, p. 08). The providential State - referred to by Giandomenico Majone as “Positive state” - witnessed its main action bases, its very foundations, the power or taxing and spending, collapse. Then, it was necessary to remove the State from the role of economic agent, in the direct intervention mode - by means of state-owned companies - allowing private parties to act as protagonists in the economy. This was the period of privatization and reduction of state participation in several economic sectors, such as the public services.

Regulations are verified (i) in the possibility of the Government to issue them for regulating its own actions (or as a form of regulating the law or organizing its functioning, having as normative basis the constitution itself); and (ii) in the conformation of the actions of private parties, based on the law. The regulation, according to Gustavo Binenbojm (2014, p. 163), may be promoted by the Chief of the Executive Branch or specialized entities:

Regulation is the genre whose types are (i) presidential regulation and (ii) sectorial regulation. While presidential regulation aims at a wider scope and generality, sectorial regulation has its incidence spectrum usually restricted to the regulated sector (economic or social). Here, the distinction criterion is basically the incidence spectrum of the regulatory rules. Therefore, regulatory entities also exercise, together with the President of the Republic and other administrative authorities, the regulatory function. Such function is the very expression of the agency's list of duties not fully linked to the law (so called discretionary). These duties may result in the practice of concrete (individual) or normative (generic and abstract) administrative acts.

And it continues:

Another classification is the one distinguishing the autonomous from performance regulations. The former are set forth in article art. 84, VI a, of the Constitution (in the wording as per EC no. 32/01), besides being implicitly

\(^{39}\) André Cyrino indicates that some specialists in administrative law have understood the existence of autonomous Executive Order in the previous constitutional regimens, such as Hely Lopes Meirelles, Sérgio Ferraz and Sérgio Andréa Ferreira (2005, ps. 95/96).

\(^{40}\) It is interesting to as certain the opinion of André Cyrino (2005, p. 99) on the reserve of authority for the themes which may be approached by the autonomous regulation, which would eliminate the possibility of issuance of a law by the Legislative Branch: “The autonomous regulations are issued based on a normative authority, with direct grounds on the Constitution, excluding the authority of the Legislative Branch”.
allowed in the constitutional systems, under specific conditions, while the performance regulations are set forth in article 84, IV. (BINENBOJM , 2014, p. 163)

Meanwhile, approaching the current Brazilian context of public works again, we defend an immediate solution for the matter of contractual amendments and their limits, which would be the regulation, pursuant to article 84, IV of the Constitution and article 65 of Act no. 8.666/93.

Further, we do not see an obstacle, in case legal provision was lacking, in promoting this discipline by means of autonomous regulation as provided for in article 84, VI of the Constitution, since this matter is not subject to stringent reservation of law. We do not understand this provision as a general bidding rule (article 22, XXVII, of the Constitution), and each federative unit might even provide for this matter. Notwithstanding our agreement that law provision ensures greater safety, and including the actual existence of this limit⁴¹, we do not see as a problem the issuance of an autonomous executive order for such purpose, since it is an internal organization of the Government, inserted into the scope of the autonomous regulatory power of the Chief of the Executive Branch, although this possibility, in a certain way, is provided for in article 40, item X of Act no. 8666/93⁴².

In summary, we understand that the exercise of the Government’s normative function is urgent. Therefore, in light of the finite nature of the public budget, the Government must establish a limit calculated based on the level of incompleteness of the agreement, on a case by case basis. For such purpose, the establishment of a transparent procedure is required, with access to the control bodies, in which the parameters adopted based on empirical studies supporting the decision making are established.

Proceduralization brings transparency required for regulatory decision, as well as ensures the technical safety and control. In every subdesign, depending on the type of work, the reason why the design was not completed might be specified. For example, in case of expropriations, the Government might justify it based on the number of houses, their number without registration and difficulty locating the owners, possessors or holders of improvements. In this regard, these are the teachings of Marcos Nóbrega:

Two basic types of transaction costs should be considered: ex ante and ex post. The main cost ex ante is that of the agreement design; the cost of establishing all the contingencies and peculiarities that may affect the agreement during its performance. Obviously, the more complex the purpose, the more expensive the stipulation of the contractual clauses will be. Thus, there will always be a completeness versus costs trade-off. Depending on the circumstances, it will be worth leaving some level of incompleteness, while expecting the possibility of further renegotiation. This seems like a simple equation, but it is not. The

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⁴¹ We have changed our understanding in relation to the article “The Public Works Agreement Amendment Limits and the Current Understanding of the Federal Accounting Court”, published in the book “Teoria do Estado Regulador” (2015, p. 135-154), in which we classified the limitation of the contractual amendments within the scope of law regulation of article 84, IV, and not article 84, VI, both of the Constitution of the Republic.

⁴² Act no. 8.666/93 only determines that the Government has criteria for the acceptance of unit and overall prices by setting maximum prices, without determining the adoption of the reference cost systems. Even if this provision existed in the law, as occurred in the Budgetary Guidelines Law, between 2003 and 2013, no problem, would arise since the law may provide for themes related to autonomous regulation, in light of the prevalence of the Legislative Branch.
correct measurement of these costs in relation to the level of completion of the agreement will reflect throughout contractual performance and will also determine the renegotiation and default costs (NÓBREGA, 2011, p. 106).

Importantly, cost-effectiveness of lack of completion of agreement should be demonstrated with concrete and empirical data, which might be challenged by the population or control bodies.

For such purpose, some regulatory flexibility should be taken into account. Two instruments could be used: executive order and the agreement. This is because there is a need for detailing some matters of Act no. 8.666/93, such as the incidence of the amount limit also on qualitative amendments, specific treatment of design errors, supervening finding of an unexpected fact and methodology for the calculation of the 25%, which, as claimed, should enable compensation between increases and decreases for the event of unilateral imposition to the contracted party and application on each amendment, for the calculation of the agreement amendment limit regarding the amount.

This executive order might also set forth that the design itself would have to expressly define the incompleteness level and that the resulting amendments would not be deemed a change of the tendered purpose.

Thus, the agreement would have to, in the concrete case, in light of the singularity of each work and each infrastructure sector, explain intentional omissions, clarifying the reason why it was not possible or feasible, through the economic or social perspective, to complete it to the fullest, although it was technically possible.

Since these amendments would not be understood as substantial, from the point of view of change to the tendered purpose, they could exceed the 25% limit as provided for in article 65. However, they must be previously warranted by lawfulness (including the principles of the Government) and, mainly, be it emphasized, cost-effectiveness must be proven. This argumentative burden is critical so that the agreements are maintained, in spite of the amount limit excess.

And what would be the role of the control bodies in this case?

Government’s actions within the limits imposed by the law must be controlled by the control bodies and the Judicial Branch, but, as a general rule, not regarding the technical and political discretion supporting the decision.

Thus, in case work is started without incorporating into the basic design all the required information usually associated with the preparation of a full design, it must assess whether the Government’s decision was grounded, including with the demonstration that it analyzed other possibilities at stake before making the adopted decision.

The control bodies would be in charge or verifying whether this procedure was performed, rather than...
the reasons (merit) leading the Administrator to this decision, unless there is no correlation, or that fundamental rights as provided for in article 5 of the Constitution of the Republic are breached, especially the rights of minorities as opposed to occasional majorities. Some consideration by the control bodies is required in face of the technical and political choices adopted by the Government.

TCU is in charge of, pursuant to article 71 of the Constitution of the Republic, the concept of the Union’s resources. Despite evolution of the concept of separation of the branches, no longer corresponding to Montesquieu’s original version, the Accounting Court is not responsible for regulating legal provisions or a specific section of the economy. Please note that the accounting courts have not been vested, as opposed to the regulatory agencies, with any form of normative power, except for its internal organization.

V - CONCLUSION

Following presentation of the preceding topics, we may reach the following conclusions:

1. The Federal Accounting Court has decided that the 25% limit must be counted separately for the sets to increases and decreases. The intent of the Court is to assess the amendment to the contracted purpose, linking it to the amount;
2. However, we do not agree with this position: the amount limit seen alone does not contribute to the defense of public bidding;
3. Incompleteness of the basic design derives from the impossibility of inclusion of all the events that may occur, as well as from financial unfeasibility – or other costs, such as opportunity – of seeking all this information, which is simply not necessary for work start and may even be dispensable for its final performance;
4. Therefore, qualitative amendments may result from project incompleteness design, i.e., intentional omissions.
5. Execution of an incomplete agreement may cause serious consequences, such as opportunistic conducts on the part of the contracted parties due to information asymmetry information;
6. Economic theories of agreements, such as the above mentioned Transaction Cost Economics, by Oliver Williamson, and that of the post-contractual rights by Oliver Hart and Grossman, have sought to describe these situations;
7. Since the work piece for unit price displays serious incentive issues, the 25% limit serves as

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44 We understand that the TCU may not determine agreement termination due to the failure to comply with the determination regarding the impossibility of compensation of item addition or removal, since such measure would breach the authority of the National Congress. We explain: the Constitution conferred on the Accounting Courts only the possibility of suspending acts and non-agreements (article 71, X of the CFRB [Constitution of the Federative Republic of Brazil]). Acts are practiced in the phase preceding the contracting, such as in the public tender. Agreements are will arrangements over which only the Congress has power of suspension (article 71, paragraph 1 of the CFRB), since such measure would threaten the legal certainty. The fact that paragraph 2 of article 71 it Court the duty of decision, in case of omission by the Congress or the Executive Branch, does not authorize it to suspend an agreement. In this regard, we cite the lesson of Carlos Ari Sundfeld: “The Constitution was clear, in its article 71 paragraph 1, when assigning the authority of suspending agreements to the National Congress only. Thus, the decision authority of the Account Court, as regards paragraph 2 of article 71, derived from the omission on the part of the Executive and Legislative branches in the suspension of agreements, may only refer to the adoption of measures within its authority scope (such as punishment of responsible people), but never upon measures that were clearly and expressly removed from its sphere of action.” (SUNDFELD, 2011, p. 136)
a way to overcome issues resulting from the agency theory;
8. But it also bears as objective the budget finite nature and the protection of some financial and economic balance, thus preventing excessive losses and gains by the parties;
9. In addition to the nature of the amount limit, we are against this calculation methodology employed by the TCU. In our opinion, there is no legal provision on separation into sets of increases and decreases;
10. Lastly, we criticize the very possibility of TCU imposing limits to the amendment of an agreement other than as provided for in the law;
11. This so happens because, in the Brazilian institutional structure, the TCU has the legal nature of control body, and it may not in any way whatsoever promote regulation of the public works agreement.
12. Thus, in order to avoid the losses resulting from inadequate basic design, the Judicial Branch would be in charge, within its normative function, of issuing orders so that each work incompletion is duly justified through the economic perspective.
13. This would be the best way of avoiding the serious losses routinely found in the Brazilian public works, resulting from deficiency in the basic design: through due planning.

All the major works are subject to the elements or are changed due to decisions made after the start of their performance, according to the singular characteristics of each enterprise. Therefore, just like in the private agreements, good solutions must be made feasible and good managers awarded, also within the scope of the administrative agreements, for the greater economy provided together with quality. In virtue of the corruption scandals, pressure from the media and increasing action by the control bodies, it must be acknowledged that the discussion in question regarding amendments in public works does not enjoy a favorable environment; nevertheless, Publilius Syrus’s sentence, written in Rome in the first Century a.d., should be brought to mind: “A plan which cannot be changed is a bad one”.

VI – REFERENCES


‘mycareerpath’ – the Ultimate On-line CPD Tool

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ABSTRACT

This work aims to identify and analyse the relevant factors to the implementation of Project Management Offices in organizations, according to internationally recognized standards by PMI - Project Management Institute, based on the concept of PMO - Project Management Office. The PMO allows companies to get benefits of process integration, one area of knowledge advocated by PMI. This is done by the PMO, a strong and emerging trend in Project Management worldwide. The literature review pointed 16 key success factors to the implementation of the PMO in organizations. The qualitative research was done with 2 Focus Groups made with 16 Brazilian experts in 2 groups of 8 experts each. They organized the 16 key success factors into 4 categories, in a model for implementation of PMO. The qualitative research (spontaneous) had interviews with 20 Brazilian experts. In quantitative research (stimulated) 64 international experts were interviewed. They are from 21 countries, in 5 continents worldwide. They are recognized as “experts” in the subject by ISO - International Standards Organization, because they work in preparing the international standard ISO 21500 – Guidance on Project Management. As a result of the work, a model was developed that could be used as reference for the successful implementation of the Project Management Office (PMO), enabling better results for projects in organizations.

Purpose

The objective of this paper is to present for discussion the results of a worldwide research about key success factors and good practices in the implementation of PMO – Project Management Office – in organizations. The authors interviewed 20 Brazilian experts in qualitative research an 64 international Project Management Experts from 21 different countries of the 5 continents worldwide in order to determine relevant factors for a successful implementation of PMO’s in organizations validated worldwide.

Design/methodology/approach

The first question was to verify and confirm the existence of PMO in organizations worldwide. The second question was to determine key success factors and good practices to the effective implementation of PMO in organizations. The 84 experts were divided into 2 groups. The author invited 20 Brazilian ex-
perts in a qualitative research and the other 64 international experts were asked to elect key success factors in a quantitative research by means of a questionnaire.

The same questions were done for the 20 Brazilian experts in project management or PMO officers in Brazil, in order to compare the results with the 64 international experts from 21 countries in the 5 continents outside Brazil. The comparison of the results from 64 international experts with the 20 Brazilian experts is very interesting and it is presented in the paper.

The author invited 16 Brazilian experts (from the group of 20) and they were divided into 2 focus groups with 8 members each group in order to compile and categorize the key success factors. Each of the 2 groups was compared to each other. Each group is supposed to confirm the other.

These two focus groups worked with intense participation of the author and they determined 4 categories of key success factors so that they have built a model of successful implementation of PMO in organizations with 16 key success factors grouped into 4 categories with 4 success factors each.

These 4 categories and the assignment of 4 key success factors into each of the 4 categories was not aimed initially and it was considered very interesting as well as it was validated for the 2 focus groups.

Findings

The 64 international experts has voted and ranked the importance of the 16 key success factor as well as the 20 Brazilian experts. The comparison of the 2 ranked lists of key success factors is also presented in the paper. The results are very interesting and the conclusion is a model for effective implementation of PMO – Project Management Office in organizations.

Originality/value

This paper presents a literature review, prior to a worldwide research in order to determine a model for implementing effective Project Management Offices – PMO – in organizations.

Conclusions

Literature review has indicated factors affecting the implementation of PMO in organizations. Subject matter international experts have listed key success factors or good practices and they were organized into categories so that we could build a model for successful implementation of PMO’s in organizations. They validated and ranked the factors as well as the model for implementation of PMO.

Keywords: Project management; PMO; Project Management Offices

1 INTRODUCTION

Project management is an increasingly recognized worldwide activity. According to the PM BOK Guide (2013), the Project Management Offices (PMO) establishes a methodological framework that provides
planning and controlling for projects through integration of the knowledge areas in PM (Project Management), with development of procedures, standards and indicators for processes of initiating, planning, executing, controlling and closing projects. The implementation of these procedures in business in general, is provided by the PMO – Project Management Office.

Literature studies determine international best practices for implementation of the Project Management Office - PMO - that increase the efficiency of the organizations and projects that may be developed in the companies, through the PMO. The methodology used is also validated in literature. According to Yin (2005), previous experience of the author of the research, in the subject of the research contributes to the development of qualitative research, selecting experts to interview, moderating the interviews. According VIEIRA and Zouain (2007), also contributes to the selection of experts and moderating focus groups (“Focus Groups”).

According ENGLUND, DINSMORE and GRAHAM (2003), the PMO concept fundamentally changes how companies manage projects and how companies “think” project management. The PMO provides methodology and formal procedures for identifying, analysing and responding to project risks. Through a Project Office, you can get patterns, forms and spreadsheets validated by use, as well as, standards, formalization of procedures processes of project management.

For the interviews as a method of qualitative research, they favor the adoption of various methods that intervene over the course of the investigation and, according RUEDIGER and RICCIO (2007), an interview allows you to check specific situations, marked by subjective traits that would not be properly seized by a “survey”. According to MORRA and FRIEDLANDER (1999), studies with other subject matter experts tend to describe what happened and why, so as to have a clear picture of the current situation.

The challenge of this type of study lies in the definition of the instances to be analyzed, which somehow was easily overcome in this study, given the real and active participation of the author in the research, from the selection of experts (“experts”) to moderation / meeting facilitation, analysis and conclusions.

Thus, to complement the methodology of qualitative and quantitative research, the author’s participation in the choice of experts and moderation of the focus groups, interviews and research groups, it was important, and is based on the concept of action research. It is a method that handles the action to do the survey (DICK, 1999): action to create change in some community or organization or program to increase understanding on the part of the researcher than is occurring. It is a method where, according to CHECKLAND and HOLWELL (1998), the researcher should always be part of the team involved with the proposed change as such in this study.

2 PMO – PROJECT MANAGEMENT OFFICE –concept and definitions

According to MORRIS & JAMIESON (2004), the implementation of PMO-Project Management Office - is a growing trend in global organizations. So the theme is mandatory in conferences, seminars and articles, as well as in academic and professional discussions due to its increasing relevance. The main roles of the PMO are:

- Serve as support to the strategic planning at the highest level of management in organizations, portfolio management and program management, including planning, controlling and reporting;
- Development of methodology, reports, tools, techniques, templates and forms;
- Guidance, guidelines, standards and support the implementation of best practices, tools, techniques and software related to project management (PM).

The PMO provides guidelines and standards by means of tools, techniques and appropriate software, reducing the problems caused by uncertainty and excessive stress generated by cheaper / faster / better projects. The PMO methodology is used efficiently establishing formal identification procedures, database, analysis, data collection, information gathering and distribution, report of results and the guidance of risk management, procurement, quality and other areas of knowledge in project management, such as documentation and communication, as discussed in VALLE (1997).

According PM BOK Guide (2013), PMI considers the Project Management Office - PMO - as an innovative concept for the successful implementation of the best practices of Project Management in the establishment and promotion of standards and methodology for Project Management in organizations as well as developing corporate governance practices and financial results for an effective integrated planning and control of projects, the critical value of success for improving management processes.

DAVENPORT, 1993, states that “the use of technology and management methodology strongly influences the improvement of the results of business processes and be addressed by strategic processes, as suggested in the figure below diagram”: 

![Diagram showing the relationship between PMO, Strategy, Projects, and Results]
3 LITERATURE REVIEW

The relevant factors to the implementation of Project Management Offices were classified by the 2 focus groups into four categories listed below:

- Organizational factors
- Structural factors and the organizational structure
- Strategic factors and knowledge management
- Personal factors, the human factor and the individual

3.2 ORGANIZATIONAL FACTORS

3.2.1 PM maturity in the organization

Several authors discuss the corporate culture focused on the management of the company associated with maturity in project management. LETAVEC (2006, page 241) addresses the role of project management offices as an unit for standards within organizations. Standardization is the highest degree of maturity, according to the maturity model of PRADO (2006). KERZNER (2006) also shows a maturity model addressing the standardization of the processes of project management in organizations. The project management offices play an important role in the standardization of data collection, processing, support for systematic decision and standardized reports.

3.2.2 Top down commitment

DINSMORE (2003, page 13) mentions the need for sponsors to the successful implementation of the Project Management Office. DIESTERER (2003, p 63) also states that top down commitment is essential to support senior management for the successful implementation of the PMO. CRAWFORD (2002, page 259) mentions that the successful implementation of the PMO depends on top down commitment with incentive and award, providing resources of the organization for education, skills and training. Top management sets the strategy. The implementation of the PMO is part of a culture of project management. Creating a culture of project management from top management is required.

3.2.3 Power given to the PMO

According LETAVEC (2006, p. 241), the successful implementation of the PMO depends on the power given to the PMO, with regard to prestige of their activity so that it can optimize the organization's resources, making decisions that affect the organization as a whole when project managers supersedes functional managers who remain leaders of pools of resources in order to develop skills and lend them to projects where PMO would centralize the power for acquisitions, procurement, contingencies, tools and standard.

3.2.4 Competence of the PMO members

RAD & LEVIN (2003, p 43) define competence as the ability to operate at certain levels of performance.
They noticed that competence does not mean just knowledge. Competence is related to results and the ability to apply knowledge to achieve goals. This is very important in the implementation of the PMO. Each type of PMO demands different skills. According to DINSMORE (2006, page 220), the skills required for PMO members and staff should be identified. Other areas of interest include recognition of the results of the PMO, customer feedback, measurement and documentation are part of that competence of the PMO itself, according to Kerzner (2006, page 217).

### 3.3 STRUCTURAL FACTORS

#### 3.3.1 Position of the PMO in the organization

KENDALL & ROLLINS (2003, p 35) mention the importance of proper positioning of the PMO in the company hierarchy and the correct positioning of the PMO in the organization chart. They suggest possible higher placement on the appropriate level of relationship with senior executives to support the decision making process. The flow of information, data collection, accountability involves a perspective of the hierarchy in the decision making process, according to LETAVEC (2006, page 226), which is linked to the position of the PMO in the organization chart.

#### 3.3.2 Size of PMO

LETAVEC (2006, p. 212) mention the size of the Project Management Office. Scaling the number of people depends on the position of the PMO and the comprehensiveness of the PMO own organizational chart. According to LETAVEC, implementation of PMO should take into consideration their functions, positioning and sizing as well as the size of the organization. The size is defined to fit the objectives, the scope, results and the functions to be performed.

#### 3.3.3 Structure of the organization by projects

CRAWFORD (2006, page 257) noticed that the PMO is connected to the organizational culture of project management that, by itself, is linked to adequate perception of the organization’s projects. This link is much higher when the company is organized by projects. The PMO support to projects and its control structure is designed to provide more employment more best practices in the Project Management environment, as well as integrated systems and project controls.

#### 3.3.4 Structured Information Systems

According to DINSMORE (2003, page 49), information systems for project management facilitate and provide good communication between professionals of projects and enable decision making by senior management and information sharing among members of the project teams in a given project or across multiple projects, a department or a business unit, according to the interest of the organization.

### 3.4 STRATEGIC FACTORS (S)

#### 3.4.1 PMO in strategic planning
KENDALL & ROLLINS (2003, p 117) define the benefits of a strategic approach to implementation of Project Management Offices. The PMO should be part of strategic planning in order to emphasize from the outset, the value proposition of the PMO. The PMO can have a deeper understanding of the existing supply chain (“supply chain”) within the enterprise and optimize it with more efficient management of the conflicts for resources. The problems of constant battles for scarce resources in the company and priorities are changing constantly minimized when the company has a strategic approach. One of the roles of the PMO is managing portfolio and programs which are sets of projects. The implementation of the PMO should be in the strategic planning of organizations that have a clear vision of the role and benefits of projects to transform their own corporate strategies into results through projects.

3.4.2 PMO in Knowledge Management

Crowford (2006, page 179) directly associates the PMO to Knowledge Management of the organizations, especially knowledge in project management. According to him, the PMO is where project management (PM) and Knowledge Management (KM) meet. The process of closure of projects, especially the capture and analysis of lessons learned provide a valuable opportunity to consolidate knowledge of of organizations through the PMO. The PMO serves as a repository of knowledge for the Project Manager and offers to their members a perspective of managing programs and portfolios. The PMO has visibility into project resources in the organization, even if the PMO does not actively manage projects in addition to internal projects PMO, and also the simple role to standardize the processes of the projects that are undertaken.

3.4.3 Internal and External Benchmarking

Bolles (2002, page 96) states that “internal and external benchmarking is an essential activity in the development of maturity in Project Management”. According to Bolles, benchmarking is an activity that has developed since 1980 for evidence of practices of other companies that lead to higher performance in comparable processes in various companies. Benchmarking was born today widely used expressions such as: “best practice” and “world class.

3.4.4 Performance Metrics

One of the main expectations of the PMO is to control projects. You do not control what you do not measure (Kendall & Rollins, 2001, p 26). According to Bolles (2002, page 56), measuring productivity and performance of projects is necessary to determine the ability to complete projects on time and within budget. Therefore, it is up to the PMO to determine performance metrics that will be monitored over projects. This is a key to its successful implementation requirement.

One of the goals of the PMO, in the case of strategic PMO or the Center for Excellence in Project Management is successfully achieve the objectives of all projects. For this, a system of methodological guidelines of Project Management, associated with a system of performance metrics is needed. The first positive results will encourage further implementation of the PMO.

3.5 PERSONAL FACTORS (P)

3.5.1 Implementation of PMO as a project
LETAVEC (2006, page 149) shows the step-by-step for the implementation of the PMO as a project, with development of a value proposition previously reviewed and approved, identifying key groups of “stakeholders” and their needs and expectations. KENDALL & ROLLINS (2003, p 33) emphasize the importance of this value proposition of the project to implement the PMO. It should show to everyone in the organization that the PMO is in business to help achieve corporate goals that are aligned with project objectives. They add the importance of showing fast results to motivate deployment ever. They suggest regular meetings to show project results to stakeholders and senior management. If senior executives are supporting the implementation of the PMO, then they will want to track the results of that implementation of PMO.

3.5.2 Time Factor for implementation

The success of the PMO depends on the time devoted to its implementation, because, according to Bolles (2002, p 87) “maturity takes time.” Everything has its time. The time factor does not mean only the period of implementation. It also means adequate to start the implementation of PMO moment. Is there an English word that defines very well the aspects related to the time factor which is called “timing”. It is necessary to provide the “timing”, suitable time for implementation of the PMO. Not very long, because rapid results (“quick wins”) will increase motivation, as LETAVEC (2002, page 41), or very fast which does not allow individuals to develop and consolidate steps.

3.5.3 Recognition and reward

RAD & LEVIN (2003, page 150) show the recognition and reward as important factors in the implementation of the PMO. Traditionally, companies have an award system for performance (“pay-for-performance”) in which people are recognized and rewarded based on their performance and contributions to projects. People like to be recognized and rewarded. Systems of recognition and awards encourage project participants to meet and exceed individual and collective goals of the projects.

3.5.4 Internal Integration of People

CRAWFORD (2002, p. 80th) analyzes the importance of internal integration of the people involved in the implementation of the PMO, as well as the importance of internal integration of people involved in the projects of the organization. The success of the PMO depends on the degree of integration across the enterprise PMO because projects usually cover a large part of the organization. The PMO can have relationships with “stakeholders” of various levels from where the requirements are collected to where the measured results are analyzed and distributed.

4. MODEL FOR IMPLEMENTATION OF A PMO IN ORGANIZATIONS

The 16 Brazilian experts grouped into 2 focus groups, with 8 members each, grouped the 16 success factors into 4 categories. It is shown below in FIGURE 2 the model for implementation of PMO in organizations with key success factors.
5 QUALITATIVE RESEARCH

Qualitative research (spontaneous) had interviews with 20 Brazilian experts in project management ("subject matter experts"). Three questions were presented to them:

Question 1: tell me about your qualifications in “project management” topic and a brief professional summary, addressing your involvement with project management offices, if any.

Question 2: do you agree that the PMO (project management office) are a reality in project management? All respondents answered yes to question 2.

Question 3: in general, which are important success factors for the implementation of the PMO in orga-
nizations? It is noteworthy here that we do not want to discuss the success of project management in organizations but to identify relevant aspects for companies that want to implement a Project Management Office (PMO).

Table 3 shows the result of the relevant aspects (key success factors) mentioned by 20 Brazilian experts. Relevant aspects (factors) were numbered 1-16 as below:

1 PM maturity in the organization
2 Top down commitment
3 Power given to the PMO
4 Competence of PMO members
5 Position of the PMO in the organization
6 Size of the PMO
7 Structure of the organization by projects
8 Structured Information Systems
9 PMO in strategic planning
10 PMO in knowledge management
11 Internal and external benchmarking
12 Performance metrics
13 Implementation of PMO as a project
14 Time factor for implementation of PMO
15 Recognition and reward
16 Internal integration of people
Table 3: Sixteen relevant Success Factors for PMO raised by the 20 experts interviewed

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The 5 most important factors are:

Table 4: The five most important factors mentioned by 20 respondents

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<th>Top down commitment</th>
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<td>1</td>
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<td>2</td>
<td>PM maturity in the organization</td>
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<td>3</td>
<td>Position of the PMO in the organization</td>
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<td>4</td>
<td>PMO in the strategic planning</td>
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6 QUANTITATIVE RESEARCH

In quantitative research (stimulated) we have interviewed 64 international experts, recognized as subject matter experts in project management by ISO - International Standards Organization, because they work in setting the international standard ISO 21 500 – Guidance on Project Management. They received a list of 16 factors identified in the literature and mentioned by the first group fo 20 Brazilian experts. They are asked to rate the factors at Likert scale of 1 to 5.
The relevant in this methodology is that the survey was conducted with 64 international experts, representing 21 countries worldwide, from the 5 continents. The international experts who participated in the survey has an average 20 years experience in Project Management, some are teachers or active consultants of Project Management in their countries.

Table 7: Distribution of PM experts by country

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<tr>
<th>Country</th>
<th>&quot;Experts&quot;</th>
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<td>Mexico</td>
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<td>Total people:</td>
<td>64</td>
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A questionnaire with the 16 relevant success factors for the implementation of PMO was prepared. The question was: “This is an important factor for the successful implementation of the PMO in organizations?”. The results are shown in Table 8, below, for a 5-point Likert scale as follows:

1 - strongly disagree  
2 - disagree  
3 - neutral  
4 - agree  
5 - strongly agree
Table 8: Sixteen relevant factors analysed by 64 international project management experts

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7 CONCLUSIONS

As the scale is 1-5, we have a central point that 3 is the neutral value. Above 3 means agreement and disagreement means below 3. We note that only one item was below 3. It was item 6 - Size PMO. It got 2.8 average. The interviewed experts considered relevant the fact that the group of 64 experts have agreed (validated) 15 of the 16 relevant to implementation of PMO factors. The survey confirmed 15 of the 16 proposed factors. These 15 factors received 3 or above 3. The average of this 15 (out of 16) factors was greater than 3 (neutral).

Consolidated the results with the factors ranked by the average obtained from the highest to the lowest, they are presented in Table 9.

Table 9: Consolidated results of the survey

<table>
<thead>
<tr>
<th>Relevant factors p / deploy PMO</th>
<th>Average</th>
</tr>
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<tbody>
<tr>
<td>2 Top down commitment</td>
<td>4,05</td>
</tr>
<tr>
<td>1 PM maturity of the organization</td>
<td>3,95</td>
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<tr>
<td>4 Competence of PMO members</td>
<td>3,95</td>
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<tr>
<td>12 Performance Metrics</td>
<td>3,88</td>
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<tr>
<td>5 Position the PMO in the company</td>
<td>3,79</td>
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<tr>
<td>14 Time factor for implementation</td>
<td>3,57</td>
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</table>
It should be noticed that the first 3 key success factors indicated here by the 64 international experts (quantitative research) are the same 3 key success factors indicated by the 20 Brazilian experts, interviewed at the initial spontaneous qualitative research, and they are in the same order.

The main factor, highlighted, is unanimous: top down commitment means the commitment of senior management for successful implementation of the PMO. It is noteworthy that the first 3 factors listed above (“top-3”) are unanimously in interviews. It is suggested that the factors presented here be more widely explored by other researchers, including information obtained from this research, broadening horizons and methodologies and adopting alternative techniques for classification (“ranking”).

It is considered, therefore, that the research was planned, conducted and performed satisfactorily, since the results achieved the goals of the research. Noteworthy is the general consensus on three major factors (“top-3”) that should be considered in the successful implementation of Project Management Offices. The model developed will help the successful implementation of Project Management Offices in companies, enabling greater efficiency in its implementation and better results for the organizations worldwide.

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Methodology for elaboration and analysis of commercial proposals for execution of civil works

Joel Valentini

ABSTRACT

The work aims to present a methodology for the preparation of commercial proposals for execution of civil works with application in bidding from private companies. The methodology uses a work plan that aims to consolidate the commercial proposal guided in its full transparency, thus enabling a prior mapping of possible deviations, misunderstandings regarding the scope to be hired and how the design of necessary resources for the fulfillment of schedule established. The methodology was based on the guidelines set forth in the TCU (Federal Audit Court) and in leading specialty literatures notoriously renowned authors. The contextualization of the proposal basically consists of the following procedures: The unburdening of the BDI / LDI rate, suggesting a standard formula with the application of maximum and minimum limits for components ensuring full transparency on that rate, traditionally very controversial and the subject of much discussions; Suggested usage budget standard worksheets, enabling a single, standardized interface between contractor and hired during the bidding process provided greater ease of equalization of proposals; established quantitative surveys and validated by the contractor through specialized technical or outsourced company staff, this procedure of great importance in the project implementation period avoiding unnecessary wear; Using the unburdening of payroll, provided their analysis provides financial gains for the reduction of the sales price.

Conclusions: As a conclusion the methodology presents tools that provide a potential gain for the routing compatible price with the scope contracted, and the considerable loss of arguments for the claims request. Guided by the broad, general and unrestricted transparency in commercial proposals methodology rewards the success of the agreement signed establishing a solid and reliable partnership between the contractors and contractors where both parties come out winners.

Keywords: Transparency, Unburdening rate of BDI / LDI, Price Compatible, Claims and Partnership

1 BASIC CONCEPTS

1.1 Selling Price

The sale price is the result of applying a margin called BDI / LDI on the Direct Cost calculated in the budget worksheet. The sale price is mainly composed by the direct, indirect and operating costs plus taxes and
expectation of profit.

1.2 Direct Costs

The direct cost is the sum of all costs from the inputs needed to carry out activities for implementation of the project and that can be raised directly from the projects, broken down and quantified in the budget worksheet. They comprise the following cost groups: manpower, materials and equipment.

1.3 BDI – Budget Difference Income

The acronym BDI comes from the English expression “Budget Difference Income”, and has the translation in Portuguese is “Additional revenue beyond the budget.” The BDI is a percentage that appropriates the costs, taxes, central administration, finance charges, risks and the margin of the planned profit.

1.4 Indirect Costs

Basically composite of: Mobilization and Demobilization; Construction site; Local Administration, Manpower Indirect and Equipment and Vehicles.

1.5 General Costs

Are percentage costs compounds according to the specific conditions of each work in general costs consist of: Central Administration; Risks and Financial costs.

1.6 Taxes

They are required taxes levied on the revenue of companies.

- Municipal tax: This is a municipal tax charged for the provision of services in the place of execution of the work or service.
- ISS - Tax service: Each municipality establishes a rate which goes from 2.0% to 5.0% over the expense of manpower in the place of execution of the work.
- Federal Taxes: They are required taxes levied on the revenue of companies.
  ◊ PIS - Social Integration Program
  ◊ COFINS - Social Security Financing
  ◊ IRPJ - Income Tax Corporate
  ◊ CSLL - Social Contribution on Net Income

1.7 Profit

Also known as margin or result, is the percentage of compensation for the contractor. Your percentage
may vary according to the strategy used by the company and/or the type of work.

2 PROPOSAL METHODOLOGY

2.1 Unburdening of the BDI rate

2.1.1 Calculation of additional charges

Complementary charges such as transportation Vouchers, Food, Breakfast, Life Insurance, Basic Food Basket, Health Plan, Medical Exams Training, Accommodation, PPEs and Tools etc. Defined by law and by inter-union agreements should be calculated on earnings price composition plus basic social charges in E Group called complementary charges and no longer in BDI rate.

According to Tisaka (2007, p22), “According to current, accounting and labor legislation, charges such as meals, transportation, safety equipment, including uniforms, hand tools necessary for the exercise of their activity, life insurance group, directly related to labor, shall be calculated and added to the social laws and complementary charges to manpower.”

2.1.2 Relocation of indirect costs

The indirect costs of Mobilization and Demobilization, Construction Site, Manpower and Equipment and Vehicles are now considered as Direct Costs were no longer counted in the BDI / LDI, for it must be presented in the form of specific worksheets as suggested models; The item Local Administration, as proposed methodology remains determined as a percentage in the BDI / LDI because according to our understanding, it is made usually by generic items difficult to calculate and control, in the case of a different item, particularly each company but through statistical studies, we have to evaluate the percentage shown is within the commonly used parameters.

According to Paulo Roberto Vilela Dias (2007, p09), “Initially we will address the BDI new concept for application by public agencies, because of the fact that the service providing companies can adopt the criterion that is most favorable to them in each case, following the concept determined by the bidding notice. However, it is important that also comply with the principles of BDI new concept.

Therefore, we are convinced that this new methodology caters to all interested in the question, in other words, auditors’ agencies, contractors and service providers.

Once the new concept of BDI establishes that some items should be transferred to the worksheet of quantities of the work, so it is possible to consider as a direct cost, such as:

- Mobilization and Demobilization of the Work,
- Local administration
- Construction site
According to TC 036.076/2011-2, “Components that are not part of the BDI: in relation to the cost components that are not included in the public works BDI, TCU has consolidated jurisprudence to exclude budget items subject to individualization and quantification. These shall include the direct costs of worksheets of the work, not the composition of BDI. These costs relate mainly to the cost of local administration, site installation works and mobilization and demobilization.”

### 2.1.3 Removal of taxation IRPJ and CSLL

The taxes IRPJ (Income Tax Corporate) and CSLL (Social Contribution on Net Income) should not be part of the calculation of LDI and no component of the sale price.

According to TC 036.076/2011-2, “The big agreement 325/2007 Plenary TCU confirmed the understanding that the IRPJ and CSLL taxes, being direct and personalistic nature, shall be borne by the individual, and therefore irregular its transfer to the Public Administration both BDI and in construction costs sheet financed with public resources. After repeated judged accordingly, this Court finally issued one pronouncement (TCU 254/2010) reads as follows:

The IRPJ - Income Tax Corporate - and CSLL - Social Contribution onNet Income - not substantiate in indirect spending be includable in budget difference income - BDI budget-based bidding, given the direct and personalistic nature of these taxes which burden the person hired.”

### 2.1.4 Rate of ISS with deductions

The nature Any Service Tax (ISSQN or ISS) has as basis for calculating the price of services with deductions, its rate varies from municipality to municipality and its rate was calculated by multiplying the price of the service with deductions.

According to TCU (2014, Guidelines for the preparation of budget worksheets public works), “The rate of ISS to be observed is established by the municipality where the work is performed. Art. 88 of the Act of Constitutional Provisions, as amended by Constitutional Amendment No. 37/2002 established a minimum rate of ISS 2% (two percent), while the maximum rate was set at 5% (five percent) by art. 8, II, LC n.º116 / 2003. The municipalities enjoy autonomy to fix the rates of ISS, provided that such limits respected.

The cited tax calculation basis may also differ depending on the local laws on the subject. Thus, by big agreement 2.622/2013 Plenary TCU determined to jurisdictional organs adopt the composition of the BDI, ISS percentage compatible with tax legislation (s) municipality (s) where they will be provided the services provided for the work, observing the form of CONCEPT: the tax calculation basis provided for in the municipal law and, on this, the respective rate of the ISS, which will be a proportional percentage of the maximum limit of 5% and the minimum limit of 2%.

To illustrate the application of the rule, use is made of inputs ABC curve exemplified in the second topic of this primer, in which the inputs are grouped by type, obtaining the following table:
Table 1  Grouping by type of inputs for determining the average rate of ISS.

<table>
<thead>
<tr>
<th>Type of Input</th>
<th>Partial prices</th>
<th>(%)</th>
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<tbody>
<tr>
<td>Equipments</td>
<td>30.792.671,09</td>
<td>56,9</td>
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<tr>
<td>Manpower</td>
<td>3.858.553,24</td>
<td>7,1</td>
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<td>Material</td>
<td>19.529.831,37</td>
<td>36,1</td>
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<tr>
<td>Grand total</td>
<td>54.161.055,70</td>
<td>100,0</td>
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</table>

Based on a municipal legislation which provides for ISS rate of 3%, levied on the total invoice amount, minus the materials used in the work, the effective tax rate would be:

$$3\% \times (1 - 36,1\%) = 1,92\%$$

Thus, the rate of ISS to be used in BDI composition would be 1.92%.

2.1.5 Profit determination in numerator of formula of BDI

The share profit member of the BDI calculated in the numerator of the formula and not the denominator.

According to TC 036.076/2011-2: “Regarding the remuneration rate, it is considered that the form of incidence in the numerator of the formula of the BDI, is in accordance with the concept presented by AACEI for setting profit margins of construction companies, as follows transcript provided in their technical guidelines for the preparation of cost estimates. It is noteworthy that the general provisions of this international institution have been accepted and recognized by the Court, like the big agreement 571/2013-TCU –Plenary.”

In this study, it is understood that the incidence of remuneration or other BDI portions on the total price of the work, with its inclusion the denominator of the formula results in the cumulative incidence of these portions with the tax rates on revenues. If a tax has increased their rate, the selling price is changed to a new level and, like other taxes and compensation also focus on the selling price, they also increase (in absolute terms) in proportion to the new level of price, going to call ‘cumulative incidence’. The opposite occurs with decreasing rate of a particular tax.

As illustrated in the table below, a possible increase of the ISS rate of 3% to 5% in the BDI composition would increase the absolute value of the compensation of R $ 88,016.79 to R $ 90,103.73, only due to the increase of this tax:
Table 2  Effects of alteration of taxes in profit percentage (profit in the denominator of the formula BDI).

<table>
<thead>
<tr>
<th>Direct Construction Costs (CD) 1.000.000,00</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Situation with original INSS</strong></td>
</tr>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>Administration Central (AC)</td>
</tr>
<tr>
<td>Risks and unforeseen (R)</td>
</tr>
<tr>
<td>Financial expenses (DF)</td>
</tr>
<tr>
<td>Profit (% in the denominator)</td>
</tr>
<tr>
<td>PIS</td>
</tr>
<tr>
<td>COFINS</td>
</tr>
<tr>
<td>ISS</td>
</tr>
<tr>
<td>Total BDI</td>
</tr>
<tr>
<td>Sale Price (PV)</td>
</tr>
</tbody>
</table>

According to André Pachioni in (p256, Public Works Prices Budget), “The fact of the profit percentage, in the case of focus on the cost of sale, vary according to the tribute of tax rates, while the percentage incident above the direct cost keeps constant, demonstrates that the budget heading is related to the direct costs and not with the sale price, so this last one must be included in the numerator of BDI formula.”

2.1.6 Formula for BDI/LDI suggested

To suggest a standard formula will adopt two situations as replacing the resolution of employer social security contribution of 20% on the payroll for a contribution of 4.5% of gross revenue.

There are several formulas for BDI rate of the composition as well as the minimum and maximum percentage for your components, specialized literature and TCU deal uniquely with no consensus among studies. In this methodology we understand that as the established concepts suggest the following calculation formulas:

\[
LDI = \left( \frac{((1 + (AC + AL + R))(1 + CF)(1 + L))}{1 - (T + CPRB)} - 1 \right) \times 100
\]  

(1)

\[
LDI = \left( \frac{((1 + (AC + AL + R))(1 + CF)(1 + L))}{(1 - T)} - 1 \right) \times 100
\]  

(2)
AC = Central Administration; AL = Local Administration; CF = financial expenses; L = Profit; R = Risks and Other; Taxes and CPRB = Social Security Contribution Gross Revenue

Which (1) is proposal formula using unburdening of the payroll and (2) is proposal formula without the unburdening of the payroll.

The percentage of maximum and minimum of the components suggested are based in the TCU judgments that vary according to the type of each project and statistical surveys.
## 2.2 Standards worksheets for proposal

### Table 3 Standard worksheet.

<table>
<thead>
<tr>
<th>Costs</th>
<th>Values - R$</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>I - DIRECT COSTS OF WORK</td>
<td>R$ 0.00</td>
<td>INFORM THE DIRECT COSTS DETERMINED IN SHEETS</td>
</tr>
<tr>
<td>II - ADDITIONAL DIRECT COSTS</td>
<td>R$ 0.00</td>
<td>( \Sigma \text{R}$ = 1+2+3+4</td>
</tr>
<tr>
<td>1 - MOBILIZATION / DEMOBILIZATION</td>
<td>R$ 0.00</td>
<td></td>
</tr>
<tr>
<td>2 - CONSTRUCTION SITE</td>
<td>R$ 0.00</td>
<td>TRANSFER TOTALS ESTABLISHED IN SPECIFIC WORKSHEETS</td>
</tr>
<tr>
<td>3 - INDIRECT MANPOWER</td>
<td>R$ 0.00</td>
<td></td>
</tr>
<tr>
<td>4 - INDIRECT EQUIPMENTS</td>
<td>R$ 0.00</td>
<td></td>
</tr>
<tr>
<td>COSTS TOTAL DIRECT COST = TOTAL DIRECT COSTS + ADDITIONAL DIRECT COSTS</td>
<td>R$ 0.00</td>
<td>( \Sigma \text{R}$ I + II = A</td>
</tr>
<tr>
<td>III - GENERAL COSTS</td>
<td>Values - R$</td>
<td></td>
</tr>
<tr>
<td>1 - CENTRAL ADMINISTRATION</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>2 - LOCAL ADMINISTRATION</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>3 - RISKS</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>4 - FINANCIAL COSTS</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>5 - PROFIT</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>TOTAL GENERAL COSTS</td>
<td>R$ 0.00</td>
<td>( \Sigma \text{R}$ 1+2+3+4+5 = B</td>
</tr>
<tr>
<td>TOTAL GENERAL COSTS + TOTAL DIRECT COSTS</td>
<td>R$ 0.00</td>
<td>( \Sigma \text{R}$ A + B</td>
</tr>
<tr>
<td>IV - TAXES + CPRB</td>
<td>Values - R$</td>
<td></td>
</tr>
<tr>
<td>1 - ISS</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>2 - PIS</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>3-COFINS</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>4-CPRB</td>
<td>R$ 0.00</td>
<td>%</td>
</tr>
<tr>
<td>TOTAL TAXES + CPRB</td>
<td>R$ 0.00</td>
<td>( \Sigma \text{R}$ 1+2+3+4 = D</td>
</tr>
</tbody>
</table>

### Calculation:

- **COST PRICE**: R$ -
- **PERCENTAGE OF LDI**: % -
- **AMOUNT DETERMINED LDI**: R$ -
- **SALE PRICE**: R$ -
## Table 4 Mobilization and demobilization worksheet.

### 1 - MOBILIZATION / DEMOBILIZATION

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>UNID.</th>
<th>DMT</th>
<th>UNID.</th>
<th>R$ COST (R$/KM)</th>
<th>R$ TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipamentos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Bulldozer D8</td>
<td>Unid</td>
<td></td>
<td>km</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Landscape loader</td>
<td>Unid</td>
<td></td>
<td>km</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Excavator</td>
<td>Unid</td>
<td></td>
<td>km</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Motor Grader</td>
<td>Unid</td>
<td></td>
<td>km</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Wheel loader</td>
<td>Unid</td>
<td></td>
<td>km</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Tank truck 10000 l</td>
<td>Unid</td>
<td></td>
<td>km</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SUB TOTAL II**  
R$ 0,00

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>UNID.</th>
<th>R$ UNIT</th>
<th>R$ TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>MISCELLANEOUS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Safety Documentation</td>
<td>Unid</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>Responsibilities Technical Notes</td>
<td>Unid</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Construction board</td>
<td>Unid</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td></td>
<td>Unid</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
</tbody>
</table>

**SUB TOTAL III**  
R$ 0,00

**TOTAL = I + II**  
R$ 0,00
### Table 5: Construction site worksheet.

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>UNID.</th>
<th>R$ / M²</th>
<th>R$ TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Provisional facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Office</td>
<td>m2</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Warehouse</td>
<td>m2</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Sanitary</td>
<td>m2</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Locker room</td>
<td>m2</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Shed to Carpentry</td>
<td>m2</td>
<td></td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Provisional connections and Support Material</td>
<td>VB</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SUB TOTAL I**  
R$ 0,00

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>DESCRIÇÃO</th>
<th>QUANT.</th>
<th>UNID.</th>
<th>R$ UNIT</th>
<th>R$ TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Several</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Water Fire Extinguishers</td>
<td>Vb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>CO2 Fire Extinguisher</td>
<td>Vb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Electric water cooler</td>
<td>Vb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>Coffee machine</td>
<td>Vb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Site construction signaling</td>
<td>Vb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SUB TOTAL III**  
R$ 0,00

**TOTAL = I + II ———>**  
R$ 0,00

### Table 6: Indirect Manpower worksheet.

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>DESCRIPTION</th>
<th>QTY./MONTH</th>
<th>R$ COST OF CHARGES</th>
<th>R$ x MONTH</th>
<th>QTY. TOTAL</th>
<th>R$ TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Indirect Manpower</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Work Safety Technician</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Safety Engineer</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Labor Nursing Assistant</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Doctor Labour</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Contract Manager</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Supervisor Engineer</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>Resident Engineer</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>Planning Engineer</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td>Building technician</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.10</td>
<td>Administrative technician</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.11</td>
<td>Foreman</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.12</td>
<td>Foreman Works</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.13</td>
<td>Topographer</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.14</td>
<td>Topography aid</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.15</td>
<td>Labourer</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.16</td>
<td>Stockman</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.17</td>
<td>Toolmaker</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.18</td>
<td>Cleaning woman</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.19</td>
<td>Driver</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.20</td>
<td>Watchman</td>
<td></td>
<td>R$ 0,00</td>
<td>0.00</td>
<td>R$ 0,00</td>
<td></td>
</tr>
<tr>
<td>1.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL**  
R$ 0,00
2.3 Surveys of quantitative

In the proposal we emphasize that even with the presence of definite projects occur many quantitative deviations, which causes considerable damage in the conduct of work, both for the contractor as to the contractor creating a path to elections and consequently wear of parts, can also bring any injustice to the other participants of the process, perchance lost the opportunity to come out winners by making more accurate surveys that the winner of the competition; To avoid or at least minimize propose that in addition to the provision by the contractor Description Memorial and Payments Criteria, is made by the technical staff of the contracting company or a company that specializes in survey quantitative that would serve as a reference for determining relative the quantitative demonstrated by the companies, so before the most relevant contract signing quantitative main would be checked and agreed between the contractor and the tenderers who represent the proposals as the new agreed quantity.

3 CONSIDERATIONS ON THE PROPOSAL

- In specific standard worksheets Tenderers may add and delete items as each work and their evaluation; All attachments must be submitted by bidders as established standards.
The proposal works with the concept full transparency for this reason it is essential that tenderers submit all relevant documentation to the project being: Spreadsheet with Standard Base Selling Price; Spreadsheets Annexes Correspondents; Statement of LDI; Statement of social laws with all charges including the additional charges; Spreadsheet Budgets with services, quantity, unit price and total Unit Prices and composition and production.

The importance of the breakdown of BDI rate, composition of social charges, can be explained by the guidelines for the preparation of budget worksheet works Public (Brasilia, 2014). "It is essential that the Administration submit the details of the BDI rate used in the framework of the bidding budget and requires bidders detailing the percentage applied in their price proposals. This need arises not only for the performance of critical components considered by the bidders, but also for the formation of values to allow the public administration memory, considering the peculiarities of each project and company perform budgets with increasing accuracy. This question is pacified in the jurisprudence of TCU, based on the Precedent No. 258/2010: The unit costs of composition and detail of social charges and BDI part of the budget that makes up the basic design work or engineering service must appear on bidding documents of the annexes and proposals of the bidders and they can not be identified by use of the term 'budget' or generic units. Segregation of BDI composition also makes it possible to assess the feasibility of the budget and possibly serve as a parameter to support the calculations of possible contractual amendments in the case of creation, extinction and tax changes during contract execution, proven impact in contract prices, in accordance with art. 65, paragraph 5 of Law 8666/93. “

4 CONCLUSION

Among the main advantages of the proposal can highlight Composition of a BDI / lean and balanced LDI; Transparency in the composition of the Selling Price; Ease equalization proposals; claims decrease.

In summary, the proposal provides practical and market trends point to a competition guided by the transparency and loyalty the proposal reinforces the Contractor and Contractor partnerships in constant pursuit of Quality and Fair Price.

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Cost Growth and Schedule Slip Analysis
A Private Equity Firm’s Perspective
Edward van Doorn

ABSTRACT
In the mining and minerals industry, projects overrun their sanctioned budget (including contingency), in real terms (excluding escalation), on average by 18 percent. This is based on 50 years of empirical capital cost estimate accuracy research. In fact, mining and minerals projects have greater cost growth and severe production misses than any other industry; this makes capital investment in this sector quite a risky prospect. This paper provides insight into the due diligence process that is used by Resource Capital Funds (RCF), a private equity firm that invests solely in the mining and minerals industry. One particular aspect of the due diligence process is described in detail, namely the project risk quantification method used to forecast potential cost growth and schedule slip. The risk analysis method used is a hybrid model based on parametric modelling (systemic risks) and expected value (project specific risks) using Monte Carlo simulation methods. This approach integrates cost and schedule and can be applied effectively to the Project Economic Assessment (PEA), Pre-feasibility Study (PFS), Feasibility Study (FS) and Execution phases of a project. Readers will gain an understanding of the overall due diligence process utilised for the life cycle of a project, with particular focus on cost growth and schedule slip risks, the methods used to analyse and quantify these risks, and what the main risk drivers are.

Keywords: Private Equity, Cost Growth, Schedule Slip, Risk, Due Diligence

1 INTRODUCTION
This paper is written from the perspective of a private equity firm that seeks a diversified investment portfolio that is not constrained by geography, commodity, phase of project or investment structure. Core investments by RCF range from approximately US$10M up to approximately US$300M, with the interest and capacity to lead an investment in a single transaction of up to approximately US$500M. Typical investments span a time horizon of four to seven years. RCF invests in portfolio companies across the capital structure and utilize investment structures such as convertible debt, equity, mezzanine financing, royalties, letters of credit and bridging debt as well as taking direct project interests. These investments can occur at any stage of the mining life cycle, which is illustrated in figure 1.
The nomenclature and level of definition required for certain stages of the mining life cycle varies from other industries, organisations and companies, as is illustrated in figure 2. There are guidelines in the mining investment world that define study phases [1], but for capital projects most practitioners within the mining and mineral processing industries are aligned with AACE International estimate classification [2,3].

In the mining life cycle, the level of geological, geotechnical, metallurgical, financial information and the knowledge on which an evaluation of a potential investment is based, increases from the exploration to the operations stage. The uncertainty in valuing a study (PEA, PFS or FS) presents a very different challenge from the evaluation of an established operating mine; each requires an in-depth financial and technical valuation methodology best suited to that stage of development and the risks involved. This overall financial and technical valuation is carried out using a financial model built in Microsoft Excel® using a discounted cash flow (DCF) approach.

To assess the potential returns, the financial model needs to simulate the financial performance of the project over its whole life. (i.e., from the next dollar invested to the closure and rehabilitation of the operation), where sustainability is of particular growing concern. The model contains a range of input variables (commodity prices, exchange rates, capital costs, operating costs, closure costs, ramp-up, sustaining capital, grades, recoveries, execution schedule, etc.) which must be forecasted to generate a range of outputs (NPV, IRR, payback period, etc.). The input variables of a DCF model are uncertain and this uncertainty (i.e., risk) has both an up and a down side. Threats are the potentially negative drivers of uncertainty leading to outcomes with lower gains, while opportunities drive potentially higher than expected gains. Being uncertain, the input variables cannot be represented by single point values (deter-
ministic), but by a probability distribution (stochastic).

When an investment opportunity is presented it will be analysed by experts within RCF. They each undertake a due diligence of the opportunity for their area of expertise and develop stochastic distributions for input into the financial model. The experts cover the following disciplines:

- Legal
- Accounting/Taxation
- Commodity and Foreign Exchange (FX) Analysis
- Trading and Market Research
- Capital Markets and Investors
- Financial Analysis
- Technical Services:
  - Health/Safety/Environmental/Community (HSEC)
  - Geology
  - Mining
  - Metallurgy and Process
  - Project Development

For the various stochastic inputs into the financial model, several different methods are used to identify and quantify the risks. However, in each case a Monte Carlo Simulation (MCS) using the @Risk® add-in to Microsoft Excel® is used to derive the relevant stochastic distributions. Several input variables are characterised by positively skewed lognormal distributions, others by normal distributions and some by asymmetrical triangular distributions.

In addition to being uncertain, variables in a DCF model can be either dependent or independent. As opposed to traditional deterministic DCF analysis, stochastic analysis requires incorporation of correlation between the uncertain input variables. This provides for more realistic simulation of the ultimate output (e.g. Net Present Value - NPV).

2 PROJECT DEVELOPMENT

One of the main financial model inputs and risks, completion risk, relates to whether a project is constructed on budget (start-up capital cost) and on time (execution schedule). Note that the execution schedule drives the start of the revenue stream, so this is critical to more than just start-up capital cost. This paper focuses on how this input and its risk is quantified and incorporated into the financial model. The project development team within the technical services function is responsible to provide the start-up capital cost and execution schedule distributions for input into the financial model, and is called upon to conduct, on average, about 20 technical deep-dive due diligence processes per year. The quality of the studies received from Owners varies significantly. Some are of such poor apparent quality that they are
rejected outright. Others are very good in quality and provide a fantastic investment opportunity. Still others have promise, but require extensive and costly revisions until deemed investment-worthy. In any case, RCF cannot simply accept the Owner evaluations.

In this paper, when reference is made to start-up capital cost, execution schedule and ramp-up, the following project development periods of time apply:

- **Start-up capital cost** = from project sanction (at the end of FS / Class 3 / FEL 3) to first feed of ore or other feedstock.
- **Execution schedule** = from project sanction to first feed of ore or other feedstock.
- **Ramp-up** = from first feed of ore or other feedstock to attaining steady state operation. For some projects it may end later, when a certain product quality and/or percent of nameplate capacity are attained.

The stigma of incomplete and incorrect studies continues to plague both major and junior mining companies. We have seen various depictions of the same story; studies that did not realistically reflect what the final project finally turned out to be. In the mining and minerals industry, projects overrun their authorised budget (including contingency), in real terms, on average by 18%. This is based on 50 years of empirical cost estimate and schedule accuracy research, reported by Hollmann (2016) [5]. In fact, mining and minerals projects have greater cost growth and severe production misses than any other industry, and makes investment in this sector quite a risky prospect. Figure 3 illustrates this succinctly for Feasibility Studies, where the capital cost growth (or overrun) is the actual cost at completion (normalised to a constant currency and time period to remove any bias driven by general price escalation and currency fluctuation) divided by the estimate cost at sanction (excluding escalation). This is presented by the “reality” curve. The “estimated” curve is the typical distribution that the mining industry attributes to a FS estimate at sanction (i.e. estimate accuracy of +/-10% at P50, within an 80% confidence interval).
Taking this a step further, the empirical accuracies surrounding earlier studies phases (PFS & PEA) have an even wider distribution, and these are collectively presented in figure 4 along with the FS presented earlier in figure 3.

Figure 3: Estimate Accuracy – Estimated vs Reality

Figure 4: Estimate Accuracy – FS, PFS & PEA
The major reasons that these cost growth and schedule slips persist is because there are two different types of risk, namely systemic risks and project specific risks, and systemic risks are largely underestimated if recognized at all. Systemic risks are those that are not unique to a particular project's scope, strategies, tactics, and so on. They are uncertainties or risks that all projects in an organisation's project system face and their impact for most projects in the "system" are relatively predictable. Research has shown that these risks are best modelled using parametric modelling for projects in all phases. Typical key systemic risks include:

- Level of project scope definition.
- Business ownership and leadership.
- Team development and skills.
- Capital cost estimate and schedule quality and bias.
- Project management/control effectiveness.
- Level of process technology.
- Level of complexity in the process and execution.

As described by Hollmann (2016) [6] and consistent with AACE International terminology [7], systemic risks are the ones that matter most, but are usually not in the risk register, and therefore are usually not well recognized or quantified. Most of these risks belong to the Owner's business management, because they control the internal system and they interact with external stakeholders. Identifying these risks is an almost impossible task for a cost engineer or risk analyst. Risk quantification failures largely result from poor internal capital and project management practices and these weaknesses are not recognised or "owned". The problem is typically not about poor base estimates or schedules and usually not even about risk events. Taken together, the project strategy, processes, practices, organization, and stakeholder interaction are a system and if this system is immature, weak or broken, these are the risks that matters most. Owners and their consultants are applying sophisticated tools that address risks that do not matter nor predict outcomes that occur. These analyses generate numbers that managers want to hear (refer to figure 3 with a typical estimate accuracy of +/-10% at P50 within an 80% confidence interval).

Mining consultants Mackenzie and Cusworth (2016) [4] agree where they state that:

- Poorly defined feasibility studies tend to result in poor project outcomes.
- Complex projects tend to be less predictable than simple projects.
- External macroeconomics circumstances can have substantial influence on the delivery of projects.
- Projects whose expectations have been set after comprehensive, detailed and integrated feasibility studies and that are then delivered by experienced, integrated teams encompassing all relevant areas of project expertise are able to deliver predictable project outcomes regardless of the inherent project factors or external macroeconomic circumstances.

Project specific risks are those that are unique to a particular project's scope, strategies, tactics, attributes, and so on. In other words, the nature of these risks and extent of their impact cannot be assumed...
to be consistent between projects. For these risks, the description and impact of each driver (usually an event or discovered condition) must be defined and estimated uniquely based on an assumed risk response. Examples of typical project specific risks drivers, their impact and mitigation are as follows:

<table>
<thead>
<tr>
<th>Risk Driver</th>
<th>Impact</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bad weather</td>
<td>Delays/poor productivity</td>
<td>Contingency plans</td>
</tr>
<tr>
<td>Unknown soil conditions</td>
<td>Increased material costs and delays</td>
<td>Testing, drilling</td>
</tr>
<tr>
<td>Land owner issues</td>
<td>Delays</td>
<td>Plan early and involve relevant stakeholders</td>
</tr>
</tbody>
</table>

However, when presented to the investor, the time for mitigation is passed. At the funding point the probability and impact of the unmitigated residual risk must be quantified based on the assumed risk response if it occurs.

Both systemic and project specific risks need to be incorporated into a model that combines them quantitatively to determine cost growth and schedule slip as shown in figure 5.

![Figure 5: Systemic and Project Specific Risks inputs](image)

Having identified what drives costs growth and schedule slip, a method is required to quantify these for incorporation into the financial model on a stochastic basis. The method found was Project Risk Quantification by Hollmann (2016) [6] and is described in detail in the next section.

**3 PROJECT RISK QUANTIFICATION**

A detailed research was undertaken to find and adopt best practice in determining how to include cost growth and schedule slip on a stochastic basis in the financial model. The search had the following crite-
ria that needed to be satisfied (aligned with AACE International principles for recommended risk analysis methods [8]):

- Incorporates systemic risks as well as project specific risks.
- Has the ability to quantify both capital cost and schedule risks.
- Aligns with AACE International Recommended Practices and the Total Cost Management Framework [9].
- Integrates estimate and schedule.
- Empirically valid.
- Practical for available in-house resources to apply on every project regardless of size, type, phase or quality.

This research determined that the methods proposed and developed by Hollmann (2016) [6] best met the criteria and backed up by AACE International Recommended Practices [10,11]. The methods involve two model integrated in a Microsoft Excel® toolset using @Risk® in the final analysis. The approach used is a hybrid method employing the following:

- Project Specific risks: an expected-value (EV) model with MSC for risk events and conditions (e.g. probability times impact) that integrates with the systemic risk model.

Figure 6 illustrates the hybrid integration of these two method into establishing a distribution for capital cost and schedule.

Figure 6: Hybrid Model – Risk Quantification
Two methods are needed because the two very different types of risk, systemic and project specific are best addressed by different methods. The parametric estimating method (based on multiple linear regression [MLR]) is used to quantify systemic risks, because their impacts are only knowable through analysis of empirical data. The expected value method (with MCS) is used to quantify project specific risks, because their occurrence and impacts are readily estimable by the team. They are brought together by using the outputs of the parametric tool as the first input in the expected value tool (at 100% probability of occurrence).

The systemic tool is intended to be used for estimates of any scope, phase, stage or AACE Class. It does not require a high quality estimate or schedule (indeed, a poor quality estimate and/or schedule is a systemic risk.) The systemic tool may be used alone (no project-specific risk analysis) for project estimates at the earliest phases (e.g. Class 5 / PEA) or in combination with the EV tool for later phases (PFS, FS, Execution, Operation) when specifics are known. This systemic tool is a simple, parametric model in a Microsoft Excel® based spreadsheet that provides a risk factor rating questionnaire (input parameters), probability distribution curves and p-tables (outputs) for cost and schedule. The curves are derived from a historical validated lognormal base model. Correlation of the cost and schedule is addressed.

By answering the risk rating questions through the due diligence process, the tool will calculate the levels of contingency that align with the desired level of confidence in an underrun/overrun. It also provides an indication of potential execution phase schedule slip (excluding study definition and ramp-up phases). An example snapshot of the systemic risk questionnaire is shown in figure 7. For each attribute, the user selects the rating that most closely represents the project’s current level of development. The selection is narrative in nature, but in the background it converts the selections to numeric values based on AACE’s level of class, where Class = 5 is least defined and Class = 3 is most defined (research shows that greater levels of definition do not significantly reduce systemic risks).

The project specific tool is a Microsoft Excel® spreadsheet that provides a risk input table (a mini-registry), a burn-rate ($/month) calculation table (used in determining cost impact of schedule delays), a cost and schedule impact estimating worksheet considering risk response, probability distribution tables and curves (outputs), and a risk ranking table (output). After identifying and inputting the risk drivers, their probabilities, and their cost and schedule impact ranges considering risk response, the tool will calculate the expected value of the cost and schedule impact of each risk and for the overall project. By also running a Monte-Carlo Simulation (using the @Risk® add-in) the tool also provides integrated distributions
of cost and schedule outcomes. The tool also includes a correlation matrix table to address risk dependencies (a fundamental step in MCS). An example snapshot of the project specific risk tool worksheet is shown in figure 8.

Figure 8: Snapshot of Project Specific worksheet

<table>
<thead>
<tr>
<th>Permit Delays</th>
<th>Assumed response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Impact (mos)</strong></td>
</tr>
<tr>
<td>Schedule</td>
<td>Low</td>
</tr>
<tr>
<td>Impact</td>
<td></td>
</tr>
<tr>
<td>Most likely</td>
<td>2.0</td>
</tr>
<tr>
<td>High</td>
<td>3.0</td>
</tr>
<tr>
<td>Schedule Months (EV)</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Two important concepts must be applied for the method to be realistic in its integration of cost and schedule. First, only quantify the critical risks. The impact of minor risks (i.e., noise) is covered by the systemic tool's historically based distribution. Critical risks (usually “red”) are those with substantive cost and/or schedule impact to the NPV (schedule is also important due to late start of revenue). Second, the risk impact must be in consideration of the potential risk response(s) if the risk occurs. This must consider the project cost/schedule objective because the response, and impact, will reflect cost/schedule trading. i.e., with enough money, one can usually minimize delay impact.

Because the parametric model cost and schedule outcomes are correlated, and the expected value cost and schedule are integrated based on assumed risk responses, the toolset is an “integrated” cost and schedule risk quantification method. If desired, a joint confidence level (JCL) diagram can be generated (a scatter plot of cost and schedule outcomes where one can see the percent of model outcomes that met both cost and schedule targets).

The cost risk ranking table also highlights those cost risks that, if they occur, will consume most or all of the cost contingency. These “special” or 'overwhelming' risks may be more amenable to “management reserve” funding (risks not in the project manager’s control).

This hybrid project risk quantification tool provides the most complete and empirically valid outcome we could find and helps meet the private equity firm’s objective to find the best investments. In order to establish the inputs into the systemic and project specific risk models and to answer all of the due diligence questionnaires, the following areas are examined in detail by RCF’s project development team:

- Scope definition
- Project execution plan
- Owner’s project team
- Schedule
- Capital cost
- Project technology and complexity
- Risk register

It can be observed that these areas of investigation are precisely the areas that were identified earlier as
being the key drivers of cost growth and schedule slip, and these are discussed in detail in the sections that follow.

4 SCOPE DEFINITION

Typical scope analysis can range from high level concepts down to granular details and the list below provides a sample of items examined:

- If a trade-off study for Owner mining versus contractor mining was performed.
- If an explosives/fuel supplier can obtain related permits, and provide design/build/operate services for the facility.
- If mitigation for naturally occurring contaminants (i.e. potential acid generating rock) in the form of lined storage dumps, collected and treated run-offs and seepages, etc. have been addressed.
- If appropriate geotechnical and hydrogeological investigations have been carried out for waste dumps, top soil dumps, tailings facility, water storage dam, plant area, access road, and ancillary facilities (soil investigation outside of the pit/underground mine being among the most prevalent gaps in many study documents).
- If condemnation drilling has been carried out under present and future project facilities’ locations.
- If mine de-watering and surface water management (with their associated diversion and collection canals, treatment ponds, etc.) have been addressed.
- If the project site and layout have been optimized to have a minimal footprint to reduce the disturbance of the environment and communities, an optimum use of existing terrain, and to reduce the utility distribution distances, etc.
- If key metallurgical testing has been completed.
- If a scope defining Memo of Understanding (MoU) exists for the supply by third parties (power, water, railway services, port services, reagents, etc.).
- If an off-take agreement or market study has defined product quality and quantity requirements.
- If engineering workshops such as Safety-in-Design, HAZOP, HAZID, constructability, and operations insurer reviews were held to capture those items that could impact upon capital cost and schedule.
- If engineering has attained the level of definition required for that particular study criteria.
- If the challenges of the project location have been fully understood and incorporated.

The degree of work that is expended to reply to the above checklist (and for other checklists in geology, mining, metallurgy, HSEC – which are not discussed in this paper) varies as the project transitions through the mining life cycle. The use of a stage gate process is encouraged, wherein the project undergoes a vigorous review at each of these phase transition points before continuing onto the next phase. The review, ideally, should be carried out by peers who have no emotional attachment to the project; a “cold eyes” review.
If the scope of a project is ill-defined or incomplete, then subsequent modifications after sanction will consequently affect the capital cost and schedule. For this reason, a very detailed questionnaire (extension of the bullet list above) is used to determine the scope definition level of a project. Figure 9 provides a snapshot of the scope definition questionnaire worksheet in the systemic tool.

![Snapshot of the Systemic tool questionnaire – Scope Definition](image)

So while the scope definition establishes the project’s “universe” we need to understand how the project team will implement the study’s next step whether it be the next study phase or the execution of the project. Let’s look at the Project Execution Plan (PEP).

## 5 PROJECT EXECUTION PLAN

The PEP is a document that demonstrates several key items:

- The Owner’s project team understanding of the project itself.
- The dynamics that are most likely to occur among the project members, company and external stakeholders.
- The measures by which the project successes can be achieved.

The PEP is a document that should be generated to clearly lay out who, what, when, why, which and how the execution will be accomplished, its objectives and its expected outcomes. The PEP, being the playbook for the execution phase, should be prepared in a timely fashion before the completion of each phase. It provides a consistent, clear and communicated plan upon which other project members can prepare their risk, cost and schedule inputs to the study. Unfortunately, the PEP is often considered as an administrative deliverable to put into the study and to fulfill a table of contents place marker. Too often it is a generic account of what the project will eventually prepare, and that it will be “detailed out in the execution phase” - certainly contradictory to the concept of being a solid plan upon which resources and project approval to the next step is sought.

Herein is a typical table of contents for a PEP that needs to be completed during the FS, and that is directed towards the execution phase (note that a less detailed discussion of the PEP for the execution phase is also addressed in the PEA and in the PFS):

- Role of the Owners project team.
• Governance requirements (including financing & conditions precedence, etc.).
• Allocation of scope among parties (Owners, contractors, technology providers, vendors, etc.) with roles, responsibilities and organization charts.
• Licenses, permits & approvals management plan.
• Health and safety management plan.
• Environment and community management plan.
• Engineering management plan.
• Procurement and contracts management plan.
• Construction management plan.
• Pre-commissioning and commissioning management plan.
• Quality management plan.
• Operational readiness management plan.
• Risk management plan.
• Schedule management plan.
• Capital cost management plan.
• Project controls and reporting management plan.

For the execution phase the PEP, prepared in the FS, should discuss in detail how the project will be managed. The roles, responsibility and accountability for each of the Owners project team members should be spelled out along with an organization chart indicating, ideally, one link to the Owner’s corporate structure. The team’s objectives towards the project successes and the quantification of the Key Performance Indicators (KPI’s) are fundamental. The KPI’s could be composed of certain design criteria features (production quantities and specifications, utility consumptions) and of typical project management criteria (safety targets, environmental compliance, capital cost and schedule).

The project will usually engage a contractor to carry out an EPCM, EPC or some hybrid thereof to assist the Owner’s team in the execution phase. The PEP should relate how various trade-offs were conducted to arrive at the Owner’s decision and justification to settle on their choice of contract mode. Similarly, the contractor’s team’s roles, responsibilities and accountability need to be matched with the Owner’s team. Figure 10 gives a snapshot of the PEP systemic risk tool questionnaire worksheet.
In order to develop and execute the project execution plan, it is necessary to have an integrated Owner’s team in place.

6 OWNER’S TEAM DEVELOPMENT

A key factor for the success of a well-managed study and the overall success of the project, is a qualified integrated Owner’s project team. Integrated means that all key functional representatives are identified, specific responsibilities are assigned, decision making authority is clear and that it is aligned with the PEP. The assignment of an experienced and qualified Owner’s team cannot be overemphasized. Members of the team must possess a project management and execution background commensurate with the scope and complexity of the project. For example, a small Owner’s team is most likely unable to manage an EPCM type contract, and will attempt to transfer risk and responsibility to the contractor by choosing an EPC lump sum type contract. However, research shows that lump sum contracts are still subject to potential cost growth and schedule slip, at the Owner’s expense, if there is a weak Owner’s team (e.g., due to late changes, indecisiveness, etc.).

It is also important to determine if the Owner’s project team has been a part of the whole scope definition process, and has sufficiently questioned its study consultants’ outcomes. A lack of managing and interrogating study consultants is often a prevalent study gap. A snapshot of the team development systemic risk worksheet is shown in figure 11.
7 EXECUTION SCHEDULE

A detailed analysis of the execution schedule is performed to a level appropriate to its stage in the mining project cycle. Each major element of the execution schedule is examined and its overall quality and bias is assessed. The outcome of the assessment are inputs into the systemic model. A small sample of the criteria used to rate the quality of the execution schedule include the following:

- Reference schedule data quality, confidence in it, and its applicability to the project.
- Owners schedule knowledge and experience with the specific project type, conditions, environment, strategies, etc.
- Schedule deliverable quality (Basis of Schedule) alignment with best practice for the current stage.
- Integration with other elements (capital cost, WBS, etc.).
- Schedule “health” check using off the shelf schedule diagnostic software (i.e. checks missing logic, logic density, number of critical activities, hard constraints, negative float, insufficient detail, number of lags, number of leads, linkage density).

The execution schedule is also examined for any bias, whether deliberate or not. An aggressive (low duration) bias increases risk and vice-versa. The bias is rated through schedule quantitative validation and benchmarking.

The execution schedule is typically one of a study document’s most hastily done sections. Part of the reason lies with an Owner’s unfamiliarity with the intricacies of a well-developed schedule (the reality of poor quality schedules is one reason that CPM based risk models are not a practical tool for analysis). The following provides a sample of items examined:

- Environment and license/permit approvals are key to many schedules. Their activities need to include enough detail to at least define the major activities in the cycles leading to transition points (i.e. submittal preparation, regulatory review, replies to comments, approval). Often the key licenses are not tied into early construction work activity.
- Activities for non-controlled project activities (e.g. government controlled), but required for the project (e.g. roads, power, port, etc.).
- Owner activities such as land acquisition, project funding, recruitment & training of operators to support any mine pre-stripping and plant start-up, and delivery of first fills should be represented. Often schedules only have engineer/contractor’s scope.
- Careful attention to holidays and work hours which may be different for engineering and procurement activities’ workdays in the office than for site workdays.
- Activities that are near critical can become critical as a schedule is not static during execution.
- Generic or same durations should not be used for similar activities (i.e. tender & award, fabrication, installation), since many durations are unique to their specific case.
- Resource loaded at FS stage, as they will influence activity durations; and apply the correlating productivity factors for the project location.
• Account for weather phenomena in the schedule by identifying yearly windows through which some activities’ productivity/duration may be affected.

The majority of the schedules prepared in studies are deterministic and do not contain a schedule contingency. Schedule contingency as defined by AACE is “an amount of time included in the project or program schedule to mitigate the effects of risks or uncertainties identified or associated with specific elements of the project schedule” [17]. Like start-up capital cost, execution schedule duration is uncertain, but industry is not including any contingency in their schedules, and it is recommended that they do. Figure 12 below shows how schedule contingency or a buffer needs to be added to a CPM deterministic schedule to arrive at the baseline schedule. It is advisable that the contractor will target the deterministic schedule end date, and the Owner will have the target date up their sleeve for any schedule slip scenario that might occur. Note that if the target date is a hard constraint for the Owner, the base schedule will need to be optimized to allow for inclusion of schedule contingency.

![Figure 12: Schedule Contingency](image)

8 START-UP CAPITAL COST

Similar to execution schedule analysis, a detailed analysis of the start-up capital cost estimate is performed to a level appropriate to its stage in the mining project cycle. Each major element of the start-up capital cost is examined and its overall quality and bias is assessed. The outcome of the assessment, including a bias rating, are inputs into the systemic risk model. The quality of the capital cost is rated using the following criteria (small sample only):

- Reference estimate data quality, confidence in it, and its applicability to the project.
- Owners estimating knowledge and experience with the specific project type, conditions, environment, strategies, etc.
- Estimate deliverable quality (Basis of Estimate) and alignment with best practice.
- Integration with other project elements (schedule, WBS, etc.).
A snapshot of the estimate quality criteria table from the systemic worksheet questionnaire is shown in figure 13.

Figure 13: Snapshot of estimate worksheet questionnaire

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>CLASS 5 (PEA)</th>
<th>CLASS 4 (PFS)</th>
<th>CLASS 3 (FS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulk Materials</td>
<td>(Earthworks, Concrete, Structural Steel, Architectural, Piping, Mech/Elect/Instr Bulks, Insulation, Painting)</td>
<td>(From initial GA drawings and sketches.)</td>
<td>(From plot plans, GA drawings.)</td>
</tr>
<tr>
<td>Bulk Quantities</td>
<td>None</td>
<td>From initial GA drawings and sketches.</td>
<td>From plot plans, GA, and design drawings.</td>
</tr>
<tr>
<td>Bulk Pricing</td>
<td>None</td>
<td>In-house data</td>
<td>Budget Quotes (major bulk materials), In-house data</td>
</tr>
<tr>
<td>Installation (Man-hours)</td>
<td>% of installed equipment</td>
<td>% of equipment or preliminary</td>
<td>Man-hours</td>
</tr>
</tbody>
</table>

The start-up capital cost is also examined for any bias, whether deliberate or not. An aggressive (low cost) bias increases risk and vice-versa. The bias is rated through capital cost quantitative validation and benchmarking.

Other start-up capital cost based systemic risk drivers include:

- **Estimate exclusions** – Exclusion listed in the basis of estimate provide an insight into any items that are planned to be expensed or shifted elsewhere, or simply ignored. Common items include remediation, mitigation, software, business support.

- **Percent of costs for major equipment** – Research from IPA shows that major mining (e.g. Owner mining equipment fleet), process and electrical equipment are less uncertain than other costs in the estimate, and therefore an adjustment is made in the systemic model to accommodate this.

### 9 PROJECT TECHNOLOGY AND COMPLEXITY

Capital costs and risks increase when the level of project technology (for new technology and material impurities/process severity) and complexity (for process and project) are increased. These four categories are examined for each project and rated for their influence:

- **New technology**: employs feed and/or chemical/metallurgical reactions that have not been demonstrated in commercial use; involves major equipment that has not been commercially proven or one that uses new and unproven materials in its fabrication; involves a new combination of feed or conveyed material and equipment.

- **Conveyed material impurity or characteristics (severity) concern**: When a feedstock, product, or conveyed material has physical or chemical characteristics that cause significant design development and/or material selection concerns, the risk of late design change increases. This is because it is more likely that late changes will occur as ways of dealing with the difficult material properties or as problems show up in commissioning that require rework. Mining and metallurgical projects are inherently subject to this risk because its solid and slurry feedstocks and intermediate products tend to vary in
properties; e.g., clog, surge, corrosion, abrasion, and so on.

- **Process or facility complexity**: measures the extent and integration of the physical work breakdown structure. The least complex is replacement-in-kind of a single item (e.g., a crusher drive). The most complex is a major integrated program or system with many physically linked scope elements. Anything that increases the dependency of the cost of one project element to another tends to increase cost risk. This is because when systems are integrated or dependent, there is less likely to be a low cost element to balance the high ones, and a problem with one process step tends to cascade to design and operation of the next. Also, mining projects often include significant infrastructure scope that must be integrated with the mine/plant requirements and this adds complexity.

- **Project execution complexity**: The prior items dealt with the physical process. This deals with the project organization and resources, and project execution strategy and plans. It recognizes that cost risks tend to increase when the number of parties (contractors, venture partners, etc.) increase and communications and coordination become more difficult. Risks also increase when novel and/or more complex practices and approaches are tried. The practices may include contracting methods, schedule logic, inspection techniques, organizational structures, communication methods, or any other element of the plan that affects performance. Once the project team loses the moorings of past practice, they are more likely to make plan changes or improvements as the project goes along (i.e., trial and error).

This concludes the key items that drive the systemic risks and focus is now directed towards project specific risks and the risk register is a good place to start.

## 10 RISK REGISTER

Project specific risks are conditions and events specific to the project scope and strategy. These risks are logged into what is termed a risk register. A wide variety of risk registers are encountered in studies which, similar to the PEP, seem to be more often than not a generic item to check off as a “table of contents” exercise, rather than the valuable management tool which can lead the project to success. A risk register is a constantly changing document which is conceived during the PEA and continues on through the PFS, FS, execution, operating and closure phases. The risk register is at hand’s reach for the leads of the Owner’s project team throughout each of the phases. It is a document that is updated frequently for its assignment of risk owners, status of mitigation plans and identification of new or emerging risks. By its very title, a risk register's contents dwell on negatives, but an important and often overlooked part of the register are opportunities. Opportunities are upsides to the potential investment in the project (special efforts should be implemented to capitalize on those; don’t leave them to stagnate in the register).

A sample of project risks that we often see not fully addressed in a risk register are:

- Environmental and social compliance actions for permits and licenses are not accounted for adequately.
- Resource, geotechnical and hydrogeological drilling is not in tandem with project phase requirements.
- Mine design and methodology selection is not in line with project phase requirements.
- Metallurgical testing is not in tandem with project phase requirements.
- Water sources are not located or tested for quality and quantity.
- Operations and maintenance inputs are not accounted for in basic design, and in early workshops.
- Construction early works, construction facilities/utilities and support issues are not fully planned out.
- Environmental controls during construction are not accounted for adequately.
- Weather windows and other factors affecting productivity, and mitigations, are not fully understood.

The top mining risks are (in no particular order):

- Resource nationalism
- Labor skills shortage
- Infrastructure access
- Cost inflation/escalation
- Project execution
- Social license to operate
- Price and currency volatility
- Capital funding
- Corruption and fraud
- Access to water and energy
- Joint venture partner issues and agendas
- Land use competing demands
- New technologies
- Increased regulation
- Community activism

The project specific risks identification starts with the risk register provided by the Owner. From this list only those risks related to capital costs and schedule are extracted. It should not include operating, production, revenue and similar items that put a project’s return on investment at risk, as these are covered by other financial input variables and other departments within the private equity firm. From this list only critical risks are considered. Critical risks are typically those where the maximum expected value will exceed 0.5% of the total project costs (e.g., for a $100 million project, this would be $0.5 million). Risks below this threshold tend to be “noise” covered by the outcome of the systemic risk analysis model.

The risk matrix is reviewed and some risks that were thought to be critical are downgraded to non-critical and removed from the register and vice versa. This list is augmented with critical risks that are identified
by the due diligence team which were not included in the original risk register. It is also important to identify any risks on the register that are considered systemic risks or escalation/foreign exchange risks. This avoids doubling up on any risks. For example, the general level of geotechnical investigation is rated as a systemic, definitional risk; however, if the geotechnical study identifies a “specific” anomaly with a potentially severe impact and if the anomaly turns out to be dominant, that risk may be added as a project specific risk over and above the systemic background uncertainty.

11 OTHER INPUT VARIABLES

Other financial input variables that the project development team covers in conjunction with other departments include:

- Escalation and Foreign Exchange (FX).
- Ramp-up.
- Operating costs.
- Closure and rehabilitation costs.
- Deferred and sustaining capital costs.

Like start-up capital costs and execution schedule, these input variables are also uncertain and are modelled on a stochastic basis. They are typically not primary drivers of the economic viability of a project, but in certain circumstances may have a profound impact. A limited discussion on these is included below.

11.1 Escalation and FX

When considering escalation, some important differentiations need to be made between escalation and inflation and subsequently between a contractor's escalation and Owner's escalation:

- Inflation is represented by a country's Consumer Price Index (CPI) which measures changes in the prices paid by consumers for a basket of goods and services. Many contractors and Owners use these in their capital cost estimates, but almost none of the CPI components are items in a mining capital cost estimate, and is therefore a poor choice.
- Contractor's escalation: Measured using published indices such as Chemical Engineering Plant Cost Index (CEPCI) and Mining Cost Service (MCS) Indexes. These indexes are composite indexes representing the cost of a typical chemical plant (CEPCI) and mine (MCS). However, they reflect costs to a contractor (e.g. wages, bulk materials, etc.), not the price an Owner pays for services (e.g. bid prices).
- Owner's escalation: Measured using actual sell price that Owners pay for services. IHS CERA is one company that has a Downstream Capital Cost Index (DCCI) that effectively measures Owner's escalation.

From 1986 to 2002 escalation tended to align with inflation (CPI-USA: average 3% per annum) which is in the historical long term 3% per annum range (1981 to 2016). The period from 2003 to 2014 however, was in the commodity “super cycle”, and Owners escalation (DCCI: average 6.4% per annum) was much higher.
than inflation (CPI-USA: 2.3% per annum). Figure 14 illustrates the three types of escalation effectively, and shows the importance of their differentiation.

**Figure 14: Inflation vs. Contractor Escalation vs. Owner Escalation**

The Owner’s escalation risk was often the greatest project risk during the commodity boom, but was largely ignored in most project estimates. The effect of this is clearly seen when we compare an internal dataset of 63 projects from 1965 to 2001 by Bertisen (2008) [14] to an internal dataset of 45 projects from 2005 to 2013 by Haubrich (2013) [22]. The mean cost overrun (including escalation) in the 1965 to 2001 period is 1.25, and 1.53 in the 2005 to 2013 period. The combined mean for the 1965 to 2013 period is 1.38. Currently (2016), we are experiencing a very low to even slightly negative escalation period, but another price resurgence cycle will occur at some time in the future and, as a risk, a probabilistic method to forecast escalation needs to be considered. The financial model is constructed in real money terms, which do not incorporate the effect of general inflation. Costs however, may rise in real terms (escalation) in each period by more or less than the general rate of inflation, as discussed above. Because escalation is uncertain it also needs to be modelled stochastically, especially in a heated market. This can be accomplished for the price indices according to Hollmann (2016) [6] by using a PERT distribution, with the most likely value provided by our in-house economist, along with high and low historical inputs defining the range.

Because materials and services are often obtained from multiple countries using different currencies than the base currency, capital costs are also exposed to foreign exchange risk. The uncertainty in costs due to fluctuating exchange rates are also modelled internally by the commodity and FX department. The extent of FX exposure varies from project to project, and the risk is handled either by an allocated budget amount in the capital cost (similar PERT distribution approach as escalation could be taken, as described above) or through a hedging program.
11.2 Ramp-up

Ramp-up occurs from first feed of ore or other feedstock until the plant is operating near or at steady-state with normal production crews. The Rand study by Myers et al (1986) [13] had as a key observation that both the ramp-up duration and cost were driven by operational problems that arose. These in turn were driven by the following:

- Level of new technology in the process.
- Materials handling difficulties.
- Project management approach.

The direct impact of ramp-up delays are:

- Additional capital costs to fix the problems encountered. These costs if significant are usually treated as separate debottlenecking projects and do not form part of the base capital costs.
- Delayed revenues.

A proposed ball-park ramp-up systemic risk quantification guideline is provided by Hollmann (2016) [6], where as long as the base start-up cost and duration estimating methods address the process technology and complexity issues discussed above, then the Rand regression analysis indicate that the following distributions of start-up cost and duration can be applied:

<table>
<thead>
<tr>
<th>Probability of Underrun</th>
<th>Multiplier of Base Start-up cost or duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>0.30</td>
</tr>
<tr>
<td>20%</td>
<td>0.70</td>
</tr>
<tr>
<td>30%</td>
<td>1.00</td>
</tr>
<tr>
<td>40%</td>
<td>1.25</td>
</tr>
<tr>
<td>50%</td>
<td>1.50</td>
</tr>
<tr>
<td>60%</td>
<td>1.75</td>
</tr>
<tr>
<td>70%</td>
<td>2.00</td>
</tr>
<tr>
<td>80%</td>
<td>2.30</td>
</tr>
<tr>
<td>90%</td>
<td>2.70</td>
</tr>
</tbody>
</table>

Another method would be to incorporate the McNulty (1998, 2004) [19,20] curves shown in figure 15, and choose the type of curve applicable to the project under consideration and subsequently adjust the capital cost and ramp duration to suit. Note that type 4 projects will often result in a new project to improve the performance and/or a capital write-down.
The four types of curves are:

- **Type 1** - Mature technology used, standard equipment selected, thorough pilot scale testing.
- **Type 2** - Some prototype equipment, first licensee, pilot scale testing incomplete or conducted on non-representative samples, inadequate FEL for portions of the scope of work.
- **Type 3** - Limited pilot scale testing, poor characterization of feed, fast track schedule, serious design flaws.
- **Type 4** - Little continuous testing, equipment downsized, complex flowsheet, poorly understood process chemistry.

Additional items shared by type 2, 3 and 4 include characteristics that are virtually all systemic in nature:

- Owners had a promotional or overly aggressive attitude.
- The Owners had very little day to day engineering input.
- Driving forces underlying the project were ill-conceived.
- The ore receiving and preparation areas received little attention.
- Hands-on training of the workforce was inadequate.
- There were serious engineering deficiencies.

These suggest that a “follow on” of the execution phase systemic analysis (when the start-up plan is com-
plete) would provide a clear indication of ramp-up success.

Mackey and Nesset (2003) [21] examined several mining projects and determined their corresponding type:
- Type 1 and 2 – copper/gold mines and mills, lead/zinc mine and mill, copper smelter.
- Type 3 and 4 – Pressure acid leach (PAL) laterite nickel plants.

The study curve has been added to emphasise what is typically encountered in studies, and shows the optimism bias inherent in many Owners and their respective study consultants. The McNulty (2004) [20] curves however do not show the extremes of behaviour – the very quick and the complete failures. Some projects such as gold CIP plants and copper SX/EW, are examples where design capacity is sometimes reached in a few weeks.

11.3 Deferred and sustaining capital

Deferred or expansion capital costs are used to acquire new capital items and install them in the operating mine and processing plant. These are capital items needed to increase the capacity of the mine and/or facilities. The uncertainty of these projects are very similar to the uncertainty of the original capital projects and are analysed and treated in the same manner in the financial model. A key difference is the need to define existing conditions and tie-ins and factor in the complexity of interfacing with an operating facility, and possibly doing work during a turn-around.

Sustaining capital costs, as the name suggests, means “stay-in-business” capital to maintain production and make minor improvements (or capitalized maintenance) to existing assets. They typically cover: equipment replacement, underground mine access drifts and infrastructure, tailings expansion, environmental and safety enhancements, and so on. The uncertainty of these costs are very similar to the uncertainty of the capital costs and are treated in the same manner in the financial model. One difference is that the base costs of smaller projects have a tendency to be over-estimated. This is because less rigorous estimating processes may be applied, the scope is “pots-and-pans” and estimators embed uncertainties in the base, and/or operational cultures may be punitive to overruns. This bias needs to be watched for and appropriately rated in the systemic tool.

11.4 Closure and rehabilitation costs

In general, closure costs include the physical removal of the mining and processing assets, and rehabilitation costs including fulfilling legal requirements, commitments made in the environmental plan and meeting community expectations. The uncertainty of these costs are very similar to the uncertainty of the capital costs and are treated in the same manner in the financial model. The estimates associated with closure and rehabilitation are usually AACE Class 5. Closure costs are more important for short Life of Mine (LOM) projects (i.e. <10 years), as they affect the NPV to a greater extent than longer LOM projects. However, if these costs are funded by bonding or similar approaches, some cost may be current. One “certainty” is that the requirements for these efforts will increase over time, and poor definition of “sustainability” in current plans is a systemic risk.
11.5 Operating costs

Although operating costs are frequently calculated in costs per tonne applied to the associated production level, it’s better to split them into fixed and variable costs. Fixed costs (e.g. labour) are not dependent on the production level for a given facility, whereas variable costs are dependent. Stochastic input distributions for variable and fixed operating costs are also determined based on a detailed due diligence process. Similar to capital costs, operating costs are usually underestimated, but unlike capital costs, operating cost empirical data is scarce. An in-depth discussion on how stochastic distributions for operating costs are obtained is a topic for another paper, but are briefly mentioned here because of their importance.

12 CONCLUSION

In this paper, we have briefly covered the overall due diligence process that a private equity firm undertakes while concentrating in more detail on the effort that the project development team undertakes during this process. Two aspects of this process concern the input of integrated stochastic capital cost and schedule distributions into the financial model using methods that apply to all phases of a project. The project risk quantification model uniquely addressing systemic and project specific risks in a hybrid approach was introduced and the due diligence process used by the project development team was generally discussed. The main elements of scope, PEP, team, schedule, capital cost and complexity to determine systemic risks were outlined and the process of project specific risk quantification was discussed. Other items like escalation, FX, sustaining capital, ramp-up, operating costs, and closure were briefly discussed and are worthy of further discussion and analysis.

The project risk quantification methods used are invaluable in providing an unbiased quantified method to model capital costs and schedule uncertainty for potential investments. Ideally, as investors, we would like to see Owners and contractors use this exact or similar approach in their analysis and we encourage them to do so. There is a continued need to educate not only the mining industry but other industries as well on improved risk quantification practices, and it is hoped that this paper advances this cause.

13 REFERENCES


Use of construction management softwares by construction firms in Kenya

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ABSTRACT

Purpose of this paper (mandatory)

The purpose of this paper is to establish the extent to which construction firms in Kenya are using construction management software tools to manage their construction projects and the benefits and challenges thereof.

Design/methodology/approach (mandatory)

The survey method was used in this research whereby questionnaires were administered on key informants working in the NCA 1 and NCA 2 general building construction firms. These categories of firms were selected because they have the largest volume of work and thus are more likely to use specialised construction management softwares.

Findings and value (mandatory)

The majority of firms (76%) use disparate softwares mainly MsProject. The advantages of using construction management softwares are mainly ease of planning/scheduling of building activities and resources; and enhancing accuracy of estimates for higher profitability. The main challenges of using the softwares include lack of information on the softwares; lack of working knowledge of the softwares; high cost of the softwares; and minimal emphasis on structured approach to planning of building activities.

Practical implications (if applicable)

Greater sensitisation and training on use/customisation of construction management softwares is required in Kenya to enhance the efficiency of construction firms and the industry at large. Construction associations, softwares producers and training institutions, can offer these mitigations jointly.
Originality/value of paper (mandatory)

The paper highlights hitherto unknown advantages and challenges encountered by construction firms in the use of construction management softwares in Kenya. It is valuable to software producers, training institutions and other stakeholders as they endeavour to enhance the efficiency of the construction industry and improve its competitiveness.

Conclusions

The potential of construction management softwares in improving the efficiency of construction firms is well recognised. However in Kenya this potential is impeded by challenges that need to be addressed.

Keywords (no more than 5): construction management, softwares, construction firms

1 INTRODUCTION

Information and communication technologies (ICT) have influenced areas of design and construction in the recent years. Much new software and hardware has been developed to aid administrating, planning, designing, and executing of projects and are being implemented by construction firms in different countries over the last two decades (Durst, 2010). Of particular interest, is the uses of software based construction management systems that are intended to enable construction firms achieve greater efficiency in their operations.

Kenyan construction firms have attempted to use construction management software as a tool to aid in the management of construction projects. However, the extent of construction management software usage in managing construction projects in Kenya is largely unknown including whether the construction firms are using the proper tools to improve the quality of their construction project management process. This is despite the fact that the construction industry accounts for 5% of Kenya's GDP and employs about one million people with an estimated annual wage bill of Kenya shillings 3.2 billion (1USD= Kshs.100) (Thuita, 2011). Consequently, any effort made to further increase the productivity of the construction industry will lead to the much-desired growth of the national economy. According to industry analysts (Ndaiga, 2011), the construction sector will continue to grow as the country lays the foundation of development as outlined in the Vision 2030 (ROK, 2016).

Moreover, in Kenya delays in construction projects and improving the quality of the construction project management process has been identified as one way to minimize delays and poor planning among clients, contractors and consultants (Kimani, 2004). The use of construction management software by construction firms for planning, administering and executing of projects can therefore greatly assist in overcoming these challenges. It is therefore, a matter of great interest for the construction industry to investigate whether the use of appropriate modern tools that could enhance the quality and effectiveness of construction project management is actually taking place.

Additionally, there is need to encourage adoption of appropriate construction project management tools for the construction industry in Kenya, particularly amongst the construction firms so that they can gain
This paper reports on findings of a research aimed at finding out whether construction firms are using integrated construction management systems and the challenges in the adoption of these softwares.

2 LITERATURE REVIEW

Construction management software can be used as an effective tool for planning, implementing and monitoring construction projects in an efficient method thus improving the performance of such projects by reducing potential problems and hence the chances of unnecessary delays occurring. There are various construction management software systems available for these purposes. The trend worldwide is for construction firms to use such systems as a way of integrating their business processes because they offer numerous benefits such as: effective contract management, control of budgets and clear sight of costs, ability to coordinate the whole business from a single system and effective solution for processing tenders and quotations.

According to Durst (2010), sometimes contractors who do not recognize the value of construction management software try to get by with other generic software options. They end up tracking construction activities on many different spread sheets e.g. workers’ compensation, change orders but when business expands and they start handling several projects, they require construction-specific software. A generic software package may require a work-around to accomplish certain tasks, which, in turn, diminishes the value of a product to the contractor. In contrast, construction management software can track millions of details in one system and provide an accurate, real-time analysis of the construction company’s performance, with no risk of double entry. Good construction management software then becomes a necessary productivity tool which allows the contractor to see if the job goes off track as soon as possible and get it back on track (Durst, 2010).

Construction management software, has greatly transformed how projects are implemented. The software automates the regular project tasks from beginning to the end and it helps the construction project manager to stay on time and within budget. The software helps project managers to be more efficient as they eliminate most of their paperwork, project minutes, change orders requests, job correspondence and many other items (Andeso, 2011). Durst (2010) states that another incentive for using construction management software is that it enables the management of construction firms to stay on top of the numbers. This is important especially in the case where bonding companies want to know the financials are accurate.

Flynn (2012) stated some of the benefits of using construction management software as follows:

- Ensure Accurate Estimates - Construction projects begin with the takeoff and estimate and the more accurate the estimate, the greater the potential for profit. Project managers will be held accountable for errors and over-budget projects, which make it essential to begin each job with an accurate estimate. A construction management software solution offers features to perform fast, accurate takeoffs and then automatically pull the data into the project management and accounting processes to prevent errors and eliminate the need for duplicate data entry or recalculations. Better estimates result in better negotiating power with subcontractors whose numbers can be challenged to reduce
risks associated with bidding too high or too low. Estimators can use assemblies available in software solutions to easily swap materials for revised estimates or value-engineer a project to prevent future errors and develop tighter bids. The efficiency of a complete solution makes it easier to accumulate bid details and produce proposals quickly. And with more accurate proposals, the probability of winning more jobs and the profit potential on each project increases.

- Schedule Labor and Equipment with Ease - Accurate estimates play a critical role when scheduling labor, materials and equipment for a job. For example, accurately estimating materials will result in less waste and reduced over-orders, under-orders and re-supply delays. With a complete solution, the project manager can automatically create job budget and billing schedules and automate purchasing processes of the estimate details already in the system. This electronic “job folder” that has all project-related data in one location eliminates the risk of data not being passed from the estimator to the project manager. A more accurate estimate also provides better site management by enabling just-in-time deliveries leading to less site storage and handling.

- Simplify Document Management - With an all-in-one solution that takes a project from takeoff and estimating through job costing and project management, contractors can also better manage project documents, RFIs, transmittals, submittals, submittal packages, daily field reports, checklists and project plans. With an online paper trail, contractors can have all documents and related email messages in one place, set alerts to meet deadlines, have an audit trail to hold individuals accountable and have the documentation on hand if they face litigation down the road. End-to-end software solutions also provide safety benefits. OSHA continues to become more stringent about their requirements and pursues litigious actions against companies that do not conform. With workflow and audit trail capabilities in a complete solution, contractors can create assignable action item lists with due dates that backtrack to their critical path schedule. The system then sends reminders throughout the process allowing contractors to stay ahead, prevent delays, and avoid potentially devastating situations.

- Reduce the Complexity of Human Resource Issues - A construction management solution can help contractors efficiently manage workforce reporting and construction payroll, including government, union, workers' compensation and benefit tracking. With automated functionalities to meet the ever-changing government and construction regulations, construction business owners can reduce risks to their business.

- Increase Profit with Less Risk - A construction management software solution can help every aspect of a construction business. By reducing the amount of paperwork and streamlining processes, contractors have more time to fix or prevent problems in the field. Instead of spending an extra hour each day putting out fires, a complete solution will enable contractors to spend that time preventing problems and finding ways to increase operational efficiency and profitability.

Examples of construction management software

- Sage Construction Software - Sage 200 Construction is out-of-the-box financial and operational contract management software based on Sage 200, for monitoring contract costs and budgets while managing cash flow and relationships (Sage UK, 2012). It is ideal for medium-sized contractors, subcontractors, house builders and other construction-related companies that need to manage contracts. This software provides: Effective contract management; Control of budgets and clear sight
of costs; Integrated Contact Relationship Management (CRM); Coordination of the whole business from a single system; and A simplified solution for processing tenders and quotations.

- EasyBuild Construction Software - EasyBuild is an oracle-based suite of application software that addresses the operational requirements of the construction industry including compliance regulations, finance and project management. It enables users to manage and control a construction project by providing them with a real time snapshots of how profitable the project is with full analysis of costs, revenues, liabilities and surveyor adjustments (Easybuild UK, 2012). It affords Monitoring of profitability; Cash flow management; and One point of access to project costs, revenues, sub-contractor liabilities, valuation adjustments and final account forecasts.

- Crest Software - Crest Software offers has a combination of a Planning and Professional version that provides an integrated solution with an intuitive user interface for casual and power users alike (Easybuild UK, 2012). It simplifies creating a project schedule; allows Overview of the Project Schedule; Critical Path Analysis; and “What-if” Analysis.

- Microsoft Project - MS Project is a software application that provides project management tools to manage projects (Microsoft Corporation, 2013). The program allows users to: Understand and control project schedules and finances; Communicate and present project information; Organize work and people to make sure that projects are completed on schedule. It enables users to stay organized; Improves everyday collaboration; and Effectively manage resources.

3 METHODOLOGY

Survey research method was preferred for this study because the investigative questions called for information to be obtained from hard-to-reach respondents since most of the people involved in construction project management work at the construction sites and are quite busy and very mobile. Survey is suitable in collecting original data from the respondents and no treatment or control was introduced on the way the construction firms managed their business activities. The data was collected via use of questionnaires.

The target population data was obtained from construction firms in Nairobi registered in the National Construction Authority Register of Contractors under categories NCA1 and NCA2 (the highest classes) (NCA, 2014). These two categories were chosen because they are of the appropriate size of construction firms that are more likely to utilize construction management softwares since the value and volume of work they undertake is much higher, such that they can better afford to purchase these softwares compared to the much smaller firms. For the purposes of this study, the accessible samples of 46 construction firms that are based in Nairobi were administered questionnaires. Of this sample 30 firms returned the questionnaires accounting for 65.2% response.

4 FINDINGS
4.1 General respondent characteristics

97% of the respondents had been in business for more than five years with 87% having more than ten years suggesting that they may have started as small firms that had expanded over the years. This is typical of construction firms in Kenya that upgrade over the years as they gain experience.

For this study the number of years in business means that the findings reflect what has been happening in mature construction businesses over the past several years hence the information can be relied upon to make useful conclusions about the construction industry.

The status of the firms is further exemplified by their annual turnover as indicated in Table 1 below. The high level of turnover is an indication of the relatively larger size of projects that these firms at the top of the registration hierarchy engage in hence suggesting that they are likely to be significant beneficiaries of project management softwares in addition to their ability to afford such softwares.

Table 1: Annual Turnover of the Respondents firms

<table>
<thead>
<tr>
<th>Turnover (Kshs.)</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100 million</td>
<td>2</td>
<td>6.7</td>
<td>7.4</td>
<td>7.4</td>
</tr>
<tr>
<td>100-500 million</td>
<td>12</td>
<td>40.0</td>
<td>44.4</td>
<td>51.9</td>
</tr>
<tr>
<td>501-999 million</td>
<td>6</td>
<td>20.0</td>
<td>22.2</td>
<td>74.1</td>
</tr>
<tr>
<td>1-5 billion</td>
<td>5</td>
<td>16.7</td>
<td>18.5</td>
<td>92.6</td>
</tr>
<tr>
<td>&gt; 5 billion</td>
<td>2</td>
<td>6.7</td>
<td>7.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>90.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>No answer</td>
<td>3</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>30</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NB: 1USD=KSHS. 100

4.2 Usage of construction management software

77% of the construction firms indicated that they used construction management software to manage their construction projects. This shows a high rate of adoption of construction management software as a useful tool in the management of construction projects by the Kenyan construction firms. It is consistent with the literature review that states that the need to adopt construction management software in the construction industry arises because it is a useful tool to manage information (Durst, 2010).
4.3 Most widely used construction management software

MsProject was found to be the most widely used construction management software (96% of all respondents). This indicates that most of the construction firms either do not recognize the value of other construction management softwares or they are not aware of them and their benefits. This finding is consistent with the claim by Durst (2010) that the construction industry is notoriously slow for adopting new software technology and that software providers must do a great job of demonstrating the value a product can bring to a contractor and how that value translates into profits before they can adopt them.

4.4 Benefits of using construction management softwares

The benefits the respondents accrued from use of the softwares are similar to those of other users worldwide as indicated in literature as shown in the Table 2. It is noteworthy that although all the benefits were important, the most significant benefit that all the respondents cited was ease of planning construction activities (100%) followed by ease of scheduling labour and equipment (78%). Time overruns have been the most contentious construction project challenge in Kenya as in other countries with contractors bearing the blunt of its impact in terms of liquidated damages and poor customer satisfaction. In view of the labour intensive nature of the Kenyan construction industry and the high cost of imported construction equipment the respondents' choices are understandable as they reflect their greatest challenges. This result thus suggests that these are the matters that challenge these construction firms in the management of projects clearly highlighting the potential impact of these softwares to improve productivity and profitability of the firms. This further explains the prevalence in use of MsProject that is proficient in handling such issues.

Table 2: Software Benefits

<table>
<thead>
<tr>
<th>Software benefits</th>
<th>No.</th>
<th>Percent</th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Planning Construction Activities</td>
<td>23</td>
<td>29.10%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Schedule Labour &amp; Equipment with Ease</td>
<td>18</td>
<td>22.80%</td>
<td>78.30%</td>
</tr>
<tr>
<td>Ensure Accurate Estimates</td>
<td>11</td>
<td>13.90%</td>
<td>47.80%</td>
</tr>
<tr>
<td>Increase of Profit with Less Risk</td>
<td>11</td>
<td>13.90%</td>
<td>47.80%</td>
</tr>
<tr>
<td>Simplify Document Management</td>
<td>9</td>
<td>11.40%</td>
<td>39.10%</td>
</tr>
<tr>
<td>Reduce the complexity of HR issues</td>
<td>7</td>
<td>8.90%</td>
<td>30.40%</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>100.00%</td>
<td></td>
</tr>
</tbody>
</table>
4.5 Most Useful Components of Construction Of Construction Management Software

91% of the respondents cited project planning as the most useful component of construction management software. Procurement came second at 78% followed by equipment management/resource scheduling at 48% and sub-contract management at 44% as shown in Table 3. This shows the importance that the respondents gave to the different components reflecting the order of priority given by construction firms to the computerization of their project management process. This suggests that when the firms adopt construction management software that are stand-alone rather than an integrated system, they will first consider computerizing the project planning then the rest of the components in the order of importance as indicated in the table 3. This is consistent with the findings in literature whereby MsProject, a tool largely used for project planning, is the most widely used software. Moreover, it is consistent with the benefits outlined above further reinforcing the reasons for such selection.

<table>
<thead>
<tr>
<th>Most useful components</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payroll processing</td>
<td>4</td>
</tr>
<tr>
<td>Financial Management</td>
<td>5</td>
</tr>
<tr>
<td>Actual job costing</td>
<td>6</td>
</tr>
<tr>
<td>Managing Change Orders</td>
<td>6</td>
</tr>
<tr>
<td>Estimating costs</td>
<td>9</td>
</tr>
<tr>
<td>Sub-contract management</td>
<td>10</td>
</tr>
<tr>
<td>Equipment management/Resource scheduling</td>
<td>11</td>
</tr>
<tr>
<td>Procurement</td>
<td>18</td>
</tr>
<tr>
<td>Project planning</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
</tr>
</tbody>
</table>

4.6 Challenges of adopting construction management software

67% of the respondents cited both lack of information about the softwares and lack of personnel having adequate working knowledge and familiarity with these softwares as being the most significant challenges in adopting construction management software. This was followed by cost of the software and lack of a structured approach in their firms for planning construction activities both being cited by 40% as shown in Table 4.
Table 4: Challenges of Adopting Construction Management Software

<table>
<thead>
<tr>
<th>Software challenges</th>
<th>Responses</th>
<th></th>
<th>Percent of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of information about the softwares</td>
<td>20</td>
<td>23.50%</td>
<td>66.70%</td>
</tr>
<tr>
<td>Lack of personnel having adequate working knowledge and familiarity with these softwares.</td>
<td>20</td>
<td>23.50%</td>
<td>66.70%</td>
</tr>
<tr>
<td>Cost of the software</td>
<td>12</td>
<td>14.10%</td>
<td>40.00%</td>
</tr>
<tr>
<td>Lack of a structured approach in your firm for planning construction activities</td>
<td>12</td>
<td>14.10%</td>
<td>40.00%</td>
</tr>
<tr>
<td>Difficulty in customizing the software</td>
<td>8</td>
<td>9.40%</td>
<td>26.70%</td>
</tr>
<tr>
<td>Poor support from software vendors</td>
<td>5</td>
<td>5.90%</td>
<td>16.70%</td>
</tr>
<tr>
<td>Lack of appropriate software in the local market</td>
<td>4</td>
<td>4.70%</td>
<td>13.30%</td>
</tr>
<tr>
<td>Lack of enough work to justify the use of such software</td>
<td>4</td>
<td>4.70%</td>
<td>13.30%</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>100.00%</td>
<td></td>
</tr>
</tbody>
</table>

Some of these challenges are similar to those investigated by Mbugua (1996) and relate to challenges that hinder adoption of software applications in general whereas others have been more specific to construction management software. The results suggest that little effort has been made towards sensitising local construction firms regarding the existence and benefits of modern construction management softwares and providing them with adequate information about this. It also raises concern about the training of personnel for the construction industry and especially the development of skills for people that are engaged in managing construction projects. This coupled with the lack of a structured approach in the construction firms for planning construction activities suggests that more emphasis should be employed towards proper training and development of manpower who are involved in construction project management such that they are more exposed and better equipped to use modern software tools in their work. This finding confirms the study by Dindi (2010), which found that there is a significant lag between technology being available, and technology being taught in curriculum.

4.7 Correlations

The research then investigated the relationships between the various variables as shown in Table 5. The two variables namely years in construction business and annual turnover are correlated with a coefficient of 0.327 and have a positive relationship. This shows that those construction firms that have been in business for longer periods of time tend to have a larger annual turnover as would be generally expected. The variables years in construction business and usage of construction management software are correlated with a coefficient of 0.029 and have a positive relationship. This suggests that those construction firms that have been in business for longer periods of time have a higher usage of construction management software. This can be attributed to the fact that they are more likely to have recognised the need for such software courtesy of their longer experience in managing construction projects. However,
this relationship is not very strong as demonstrated by the low correlation coefficient and could probably suggest that some of the younger firms have embraced the use of software tools much faster than expected. The two variables annual turnover and usage of construction management software have a low negative correlation coefficient (-0.286). This suggests that the adoption of these softwares is probably influenced by other factors rather than turnover e.g. the age of the directors with younger ones being more open to ICT tools compared to older ones who tend to be more conservative – the later tend to dominate many large firms which constituted many of the respondents.

Table 5: Correlations

<table>
<thead>
<tr>
<th></th>
<th>Years in Construction business</th>
<th>Annual turnover</th>
<th>Usage of Construction Management Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years in Construction business</td>
<td>Pearson Correlation 1</td>
<td>0.327</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Annual turnover</td>
<td>Pearson Correlation 0.327</td>
<td>1</td>
<td>-0.286</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.096</td>
<td>0.149</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Usage of Construction Software</td>
<td>Pearson Correlation 0.029</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.879</td>
<td>0.149</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

5 CONCLUSIONS

The findings show that majority (77%) of the large construction firms were indeed using construction management software to manage their construction projects. It was however, noted that MsProject was the most predominantly (96%) used software, compared to the others. Given that MsProject is largely a general project management software which, though useful for managing construction projects, is not specifically designed for the construction industry projects leads to the conclusion that the uptake of construction industry specific software products is low amongst the Kenyan construction firms. This in turn prevents the construction firms from getting the full benefits of using construction management software to improve the quality of the entire construction project management process.

The most significant benefits of using construction management software to the construction firms were ease of planning construction activities (100%), scheduling labour and equipment with ease (78%) and accurate estimates and increased profitability (both 49%). This suggests that these are the most significant challenges that the contractors experience in the management of projects and highlight the potential of these softwares to improve performance. Accordingly, the above aspects are also the components that the contractors find most useful in the softwares.

Lastly, the lack of information about construction management softwares (67%) coupled with lack of personnel having adequate working knowledge and familiarity with these softwares (67%) are the major
challenges that hinder the adoption of construction management software amongst the construction firms. The cost of the softwares (40%) and the lack of a structured approach in planning construction activities (40%) were also significant challenges. This indicates that sensitization of the contractors on the availability of the softwares and their capabilities combined with provision of training for their personnel on usage of the softwares have the greatest potential to increase the impact of the softwares to enhance the efficiency of construction firms and the industry at large. Construction associations, softwares producers and training institutions, can offer these mitigations jointly. The above findings are an indication of the challenges of a developing construction industry where use of construction management softwares is still novel and hampered mainly by the lack of knowledge and information. This overshadows all other concerns.

6 RECOMMENDATIONS

In order to improve the quality of construction project management within the Kenyan construction industry, there is need to sensitize the various players involved in the management of construction projects about the existence and importance of construction industry specific software products that can enable them perform better in their work. This can be done by aggressively promoting the adoption and extensive use of these modern construction management software tools by local construction firms via forums attended by the top management of the firms where they work. These forums include those organized by contractors associations and the National Construction Authority that is mandated to administer continuous professional development programme amongst contractors.

7 REFERENCES


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National Construction Authority 2014, Register of contractors viewed 10 December 2014 www.nca.go.ke


Cost Elements to be considered in the Design of Marine Infrastructures – Jetties and Dredging

Kenneth Wong

Singapore Institute of Surveyors and Valuers

ABSTRACT

Urbanisation (cities, interconnectivity), demographics (population trend), economy (Gross Domestic Product, consumption) and geopolitics (trade blocs vis-à-vis gated community, shifting powerhouses) will be the main drivers that will increase the demand for seaborne trades and shipping activities in the future as forecasted in the Global Marine Trends 2030 report published by Lloyd’s, et al. (2013). With seaborne trades representing about 90% of world trade, and with the increasing demand for dry cargo (break bulk, commodity, container) and wet cargo (liquid bulk), the growth of the shipbuilding-related industry (bulk carrier, containership, tanker, Liquefied Natural Gas carrier) and energy-related industry (fossil energy, renewable energy) is set to continue (UNCTAD, 2014; Lloyd’s, et al., 2013) - the maritime-related infrastructure industry being no exception. The financing of marine infrastructure developments can be capital intensive. For a rough order of magnitude example, the construction of new jetties and capital dredging works for a petrochemical storage terminal located in the Southeast Asia region may require capital expenditure of circa US$200 million. With tight budget constraints, a quadripartite procurement structure comprising the lender, owner, consultant and contractor, will be pressured to multidiscipline design optimise. This paper examines at macro level, the cost elements to be considered in the design of marine infrastructures specifically jetties and dredging with emphasis on value engineering aspects and whole life cost.

Keywords: Cost, Design, Jetty, Dredging

INTRODUCTION

BSI (2010, p.3) defines a jetty as a “structure providing a berth or berths at some distance from the shore (a jetty may be connected to the shore by an access trestle or causeway, or may be of the island type)” while a wharf (also called a quay) is defined as a “berth structure backing on to the shore or reclaimed land”. Jetties and quays are used interchangeably in this paper. They are similar except that a jetty is extended further from the shore into deeper waters. A jetty is commonly constructed of an open deck supported on piles or as a solid structure with vertical marine frontage. Concrete deck is typically used, alternatively may be of steel or timber, mainly because concrete is more economical than steel and more
durable than timber. The main function of a jetty is to provide berth accommodations to a watercraft for the loading/unloading of goods or the embarking/discharging of passengers.

Dredging is defined by BSI (1991, p.10) as “the removal from beneath water and raising through water of soil, rock or debris”. Examples of equipment used for dredging include cutter suction dredgers, trailing suction hopper dredgers, grab dredgers, hopper barges and hydrographic surveying equipment. There are many reasons to dredge. Dredging can be carried out to provide a navigable waterway while dredged material can be used as fill for land reclamation or beach nourishment.

LEVELS OF COST ESTIMATE

Order of Magnitude estimates at Level 1 for jetties can be quickly build up based on functional unit rate analyses in the form of Cost per LOA, Cost per Displacement, Cost per Deadweight Tonnage (DWT) or Cost per Draught, applying relevant cost indexes where relevant. Location factors are typically used as most cost data for jetties are from international sources due to the nature of the works.

Level 2 (Concept) cost estimates are based on approximate quantities referenced to preliminary layout plans, typical cross section drawings and soil investigation data. Table 1 describes an example of a Level 2 (Concept) cost estimate summary for a jetty development. Piling and dredging works are shown as the cost drivers, which typically would be the case.

Level 3 (Front End Engineering Design (FEED) or Detailed Design) cost estimates depending on the level of development should give an accuracy rate of ± 20 per cent and ± 10 per cent, respectively. While the accuracy rate may seem low, it will diminish further when the project location is foreign to the estimator due to factors such as lack of local pricing knowledge, limited availability of cost data for comparison and fluctuating foreign exchange risk.

Example of a Level 2 (Concept) Cost Estimate Summary for a Jetty Development (25,000 to 320,000 DWT)

Scope of Works

- Capital Dredging of 2,000,000m³;
- Causeway with Armour Rock Protection, 480m Long x 44m Wide;
- Steel Pipe Piles, 1,200mm Outside Diameter x 19mm Thick;
- 1 no. Approach Trestle, 2,100m Long x 17m Wide, 24m Typical Span;
- 1 no. Loading Platform, 64m Long x 35m Wide;
- 6 nos. Breasting Dolphin;
- 8 nos. Mooring Dolphin; and
**Figure 1** Level 2 (Concept) Cost Estimate Summary for a Jetty Development (25,000 to 320,000 DWT) (Source: Author)

The cost of constructing a jetty correlates with the range of vessel sizes in which the jetty is able to accommodate. PIANC (2008, p.46) viewed the relationship between the investment costs of jetties and the sizes of vessels as almost linear. As the size of a vessel increases in terms of Length Overall (LOA), displacement and draught, the functional requirements of the jetty facility for berthing and mooring becomes more demanding. Table 1 describes the likely impacts of the increase in vessel size to the elements of a jetty.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Budgetary Amount (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dredging</td>
<td>USD 16,000,000.00</td>
</tr>
<tr>
<td>2</td>
<td>Causeway</td>
<td>USD 4,000,000.00</td>
</tr>
<tr>
<td>3</td>
<td>Piling Works</td>
<td>USD 22,000,000.00</td>
</tr>
<tr>
<td>4</td>
<td>Approach Trestle</td>
<td>USD 12,000,000.00</td>
</tr>
<tr>
<td>5</td>
<td>Jetty Structures</td>
<td>USD 4,000,000.00</td>
</tr>
<tr>
<td></td>
<td><strong>Total Budgetary Cost</strong></td>
<td><strong>USD 58,000,000.00</strong></td>
</tr>
</tbody>
</table>
Table 1 Increase in vessel size and the likely impacts to jetty elements (Source: Author)

<table>
<thead>
<tr>
<th>Increase in Vessel Size</th>
<th>Impact</th>
<th>Jetty Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOA</td>
<td>➢ More dolphin structures</td>
<td>➢ Longer berthng frontage</td>
</tr>
<tr>
<td></td>
<td>➢ Longer walkways</td>
<td>➢ Longer walkways</td>
</tr>
<tr>
<td>Displacement</td>
<td>➢ Increase in structural strength</td>
<td>➢ Greater fender energy absorption</td>
</tr>
<tr>
<td></td>
<td>➢ Greater fender energy absorption</td>
<td>➢ Increase in bollard anchor pull out</td>
</tr>
<tr>
<td>Draught</td>
<td>➢ Longer trestle</td>
<td>➢ Potential dredging works</td>
</tr>
<tr>
<td></td>
<td>➢ Higher deck clearance</td>
<td>➢ Higher deck clearance</td>
</tr>
</tbody>
</table>

Figure 2 depicts a jetty with berthing capacity of 3,000 to 80,000 DWT. The colour contrast of the structures indicates that additional mooring dolphins are required to secure the larger 80,000 DWT vessel.

Figure 2 Plan view of jetty elements required for 3,000 to 80,000 DWT vessel (Source: Author)
DREDGE MORE TO DREDGE LESS

When planning for future deepening and widening, it is economically practical to increase the current dredged depth at current dredging cost rather than deepening and widening in the future. However, owners will tend to be subjected to the justification dilemma of pay more now relative to future plans which are sensitively dependent on business and operation needs. In particular, PIANC (2008, p.48) found that private operators are less inclined to consider future uncertainties beyond a period of 10 years. Some of the factors that influence dredging decision are shown in Table 2.

The criterion in Table 2 can be quantified into monetary terms to yield reliable dredging decision-logic vis-à-vis cost threshold.

**Table 2** Examples of factors influencing dredging decision (Source: Author)

<table>
<thead>
<tr>
<th>Benefits of dredging more at current market price</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Avoid inflationary effect.</td>
</tr>
<tr>
<td>➢ Cost savings due to economies of scale.</td>
</tr>
<tr>
<td>➢ Reduction in future operational downtime.</td>
</tr>
<tr>
<td>➢ Future environmental aspects may be more stringent.</td>
</tr>
<tr>
<td>➢ Reuse dredged spoils for land reclamation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits of dredging at a later phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Uncertainty with future operational requirements and market conditions.</td>
</tr>
<tr>
<td>➢ Adopt maintenance dredging option as a financially cautious approach.</td>
</tr>
<tr>
<td>➢ A lower capital cost but with subsequent higher maintenance cost may be economically attractive as it generates earlier revenue stream, which can be used to fund future maintenance (CIRIA, CUR, CETMEF, 2007, p.41).</td>
</tr>
<tr>
<td>➢ Presence of contaminated deposits or hard materials which increases the cost of dredging and dumping.</td>
</tr>
<tr>
<td>➢ Dredging tolerance (low rate of hydraulic sedimentation) warrants dredging at a later phase.</td>
</tr>
</tbody>
</table>

Marine infrastructure owners tend to dread carrying out dredging works because they are expensive, intangible and time consuming. Dredging works also have the potential to be highly complex works when major environmental damages occur such as destruction of coral reefs, adverse sediment plume and oil spill. Sovereignty disputes may also occur where dredging works are close to territorial waters.

As such, dredging decisions are stringently made from the perspective of cost and benefit with operational needs being secondary. For example, vessels entering or exiting a port need to wait for sufficient tide due to insufficient depth of the access channel. The port operator may accept the increase in turn-around time due to lack of funding to deepen the channel and instead increase the port’s operational efficiency to reduce dwelling time.

Where dredging works will benefit two or more parties, a shared cost apportionment approach between the parties is typically negotiated in order to share the financial burden of the works.
LONG TRESTLE, LESS DREDGING OR SHORT TRESTLE, MORE DREDGING

The decision to extend a trestle seaward or to reduce its length is highly dependent on the dredge volume required for safe berthing and unberthing operations. Against metocean conditions, the decision-logic of trestle optimisation against dredging strategy can be narrowed to a matter of dollars-and-cents.

Ordinarily, the cost of dredging will outweigh the cost of extending the trestle – the dredge volume will be greater than the quantum of concrete, steel and topside equipments relative to cost. For example, for a new terminal it is more cost-effective to have a longer approach trestle with reduced dredging as compared to an approach trestle closer to shore but with greater deepening and widening of the access channel, berthing and turning basin – not forgetting the life cycle cost of periodic maintenance dredging. One example is the Progreso Pier shown in Figure 3, located in the Mexican state of Yucatán is the longest pier in the world, measuring 6.5 kilometres long. Such a long pier was necessary due to the existing limestone shelf forming the seabed, which required challenging dredging methods, ergo more costly.

On top of that, the cost of dredging will be further exacerbated should it entail complex environmental protection measures such as the need to relocate coral reefs and continuous real-time turbidity measurements. A case in point is the deepwater Khalifa Port shown in Figure 4, located in the United Arab Emirates city of Abu Dhabi, which is interconnected with the shore via a causeway stretching some more than 4 kilometres in length, in order to avoid encroaching on the Ras Ghanada coral reefs.

Dredging cost is highly influenced by project timeline as tight timeframes with short operation windows will entail mobilisation of additional dredging equipment. Another strong cost influence would be the location factor in relation to: distance between working area and dumping ground; and distance between working area and mobilisation position.
Figure 3 Satellite image of Progreso Pier (Source: NASA, 2014)
SPAN OF THE APPROACH TRESTLE

The span of the longitudinal beams supported between headstock beams in an approach trestle can be a significant cost driver. As the trestle extends seaward, shorter longitudinal beams will need to be supported by headstocks which translate to more piles required to be driven and vice versa.

Contrarily, longer longitudinal beams will require structurally stronger piled foundations and cross section geometry of longitudinal beams and vice versa. The question of adopting longer beams would then be: are the cost savings of headstock and pile quantities greater than the cost of increased structural strength of piles and beams? It is often more economical to adopt longer span beams as marine piling works are costly and pile quantities should be reduced to wherewithal.

Typical trestle span ranges between 12 metres and 24 metres. With the use of precast prestressed concrete, longer beams and slabs can be achieved with greater material savings in concrete and reinforcing steel. Yee (2001a) stressed that the use of precast prestressed concrete beams and slabs enables structures to be built: with speed; leaner; with better quality control; and more economical while Yee (2001b) underscored significant benefits to social and environment.
An exemplification of the advantage of longer beams can be found in Lekir Bulk Terminal shown in Figure 5, located in the Malaysian state of Perak, it consists of an approach trestle measuring 2 kilometres long constructed of prestressed precast concrete T-Roff girders measuring 33.5 metres in length. The long girders significantly reduced the number of pile bents and proved to be a cost effective solution.

*Figure 5* Satellite image of Lekir Bulk Terminal (Source: Google Earth, 2013)

**CAISSON OR PILE DECK**

The option of either adopting a caisson or pile deck is mostly not driven by cost but mainly on the inherent characteristics of the structures in relation to operational suitability. It is therefore not advisable during the concept stage to decide between the two structures purely on cost-effectiveness basis as these two structures both have their pros and cons, which will require careful analyses of individual structure’s performance.

Figure 6 depicts a decision tree model which can be applied as a process of elimination, when evaluating the feasibility between caisson and pile deck structures. Based on Figure 6, the structural analyses of the options is critical in determining the most suitable solution. If both options are able to perform structur-
ally, the elimination process will be narrowed down to a matter of cost and time.

Table 3 presents a comparison of the characteristics between caissons and pile deck jetties. These comparisons represent the generally accepted viewpoints of the two structures, however they should not be taken as conclusive as each analysis should be treated on a case by case basis, due to varied factors such as ground condition, dredge volume, cost of soil improvement, transportation difficulties and etcetera.

**Figure 6** Decision tree diagram for the selection between caisson jetty and pile deck jetty (Source: Author)

**Note**

On the assumption that all other resources are fully available and that there are no other design constraints, else design option will be eliminated.

Fully available resources include:
- Precasting yard and laydown area
- Specialized skill and experience
- Transportation and installation equipment
- Suitable material
- Working area and period
### Table 3 Comparison of the characteristics between caisson jetty and pile deck jetty

<table>
<thead>
<tr>
<th></th>
<th>Caisson</th>
<th>Deck On Pile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time</strong></td>
<td>Shorter (CED, 2004)</td>
<td>Longer (CED, 2004)</td>
</tr>
<tr>
<td><strong>Reusability</strong></td>
<td>Ease of movement/modification if filled with sand instead of lean concrete (PIANC, 2008)</td>
<td>Piles would be cut off at sea bed level (PIANC, 2008)</td>
</tr>
<tr>
<td></td>
<td>Potential reuse as breakwater or seawall (Author)</td>
<td>Structure would need to be demolished (Author)</td>
</tr>
<tr>
<td><strong>Construction Productivity</strong></td>
<td>Higher productivity with use of precast concrete cells (Author)</td>
<td>Labour intensive due to piling works, mix of in situ and precast concrete (Author)</td>
</tr>
</tbody>
</table>

### VALUE ENGINEERING WITH EARLY CONTRACTOR INVOLVEMENT

It can be said that the sole objective of an Early Contractor Involvement (ECI) exercise is to appreciate and utilise contractors’ expertise. As Quantity Surveyors may not be well equipped with actual construction technicalities, the ECI exercise will prove to be a great degree beneficial to a project, particularly so when the project is of a foreign location to the Quantity Surveyor. Some of the advantages experienced by Seah (2014, pp.1-6) through ECI exercises within the building industry include: greater commitment from the contractor; value engineering advises; better control of project risks; and shorter tender period. CIRIA, CUR, CETMEF (2007) ratified the adoption of ECI and found that ECI can provide significant cost savings to rock works within the hydraulic environment while IADC (2015, p.57) emphasised EPC contracts and ECI exercises as “more successful ways of approaching mega-infrastructure projects”. Some examples of the advantages experienced by the author through ECI exercises include:
ANCILLARY SITE CONSIDERATIONS

The location for the construction of marine infrastructures is often dictated by the underlying function to which it serves. For example, a jetty serving a coal mine will be used to load coal unto dry bulk barges while a quay serving a container terminal will be used for the storage and transfer of container goods. The location of the underlying function is subjected to operational and business needs which may include criterion such as navigation route, proximity to feedstocks or refineries, intermodal transport accessibility and hinterland connectivity.

The characteristics of the construction site can often be overlooked during the design stage possibly because Quantity Surveyors tend to view them as the contractor’s responsibilities to ascertain and scout for potential site issues. Ideally, Quantity Surveyors should be aware of the interface points between design, constructability and site condition as these criterion have their individual cost implications. The following are some examples pertaining to site considerations during the planning and design stage:

- A construction contract programme was initially estimated to be 13 months. Through discussions with various tenderers, the contract period was reduced to 11 months as all the tenderers unanimously agreed that the 11 months contract period was feasible.

- During a FEED preparation for a jetty, ECI exercise revealed that the piles for the approach trestle which were closer to the shore were unable to be driven with marine piling barge due to existing tide levels which afforded short construction window periods. The contractor thus proposed the use of shorter beam spans so as to enable land-based piling equipment to drive the piles that were closer to shore. This would however require the construction of a temporary access roadway for the land-based piling equipment. The Quantity Surveyor had acknowledged this constructability challenge as a point-to-consider during the next design development phase.

- In a building construction project, the use of Expanded Polystyrene (EPS) concrete for staircases and raised floors in order to reduce the volume of concrete was proposed by the contractor. The EPS composite technology was unknown to the Quantity Surveyor at the time and the value engineering alternative was adopted.

- At FEED stage, the Quantity Surveyor identified a number of existing or active quarries and borrow pits which were within proximity to the proposed revetment and reclamation site. However, contractors highlighted that they were uncertain that the identified quarries and borrow pits were able to yield sufficient quantities of the required rock characteristics and fill materials. This meant that the materials may need to be imported which will result in an exceedance of the preliminary cost estimate. The cost of imported materials is further exacerbated by local import taxes and duties. The cost estimate and contingency sum had to be increased to reflect the unavailability of locally sourced materials.
Availability of Laydown Area

Laydown areas for marine construction are typically provided for facilities such as site office; fabrication yard; equipment and material storage; temporary jetty for loading/unloading; temporary mooring facilities for service vessels; and stockpile for large volume of material such as armourstones, precast beams, piles and caissons. The suitability of the laydown area in terms of size and accessibility should be considered during preliminary cost estimate as the cost of constructing and maintaining temporary facilities such as stockpiles, roads, bridges and jetties can be very high.

Existing Environmental Conditions

Activities (Environmental Impact Statement, Environmental Impact Assessment and Environmental Monitoring and Management Plan) to safeguard the sustainability of the existing construction site and surrounding environment should be carried out at the earliest possible stage preferably during initial planning so as to establish: the approvability of planning and development permit; and the individual responsibilities of the contractor, environmental consultant, owner and authorities.

An environmental assessment (typically required for petrochemical jetties, dredging, coastal protection and reclamation) evaluates an established environmental baseline with potential impact to environmental features such as ecology, socio-economy, marine facilities, vessel navigation, cross-border impact and aquaculture.

The cost of conducting environmental assessment and monitoring can be costly and time consuming, mainly dependent upon the location of the site. For a sense of scale, these costs usually constitute circa 10-15 per cent of the overall dredging cost for a project located within the South East Asia region. Examples of typical monitoring activities may include monitoring of: oil spill; sediment plume; water quality; Secchi disc depth; and habitat while examples of typical mitigation measures may include installation of silt curtains, side-scan sonar, improvements to dredging methodology and deployment of oil booms.

The significance of proper environmental management should not be overstated. Owners will tend to be inclined to view these extra costs as a financial burden, however, the lack of properly addressing the construction impact to environmental receptors can drastically delay authorities’ approvals (specifically in countries where the environmental regulations are well defined and controlled) which may lead to detrimental multiplier effects to the end users.

Geographical Risks

Certain countries may carry more risks than others in terms of political, economy and social. Quantity Surveyors will need to identify these country risks when reviewing the financial feasibility models for marine infrastructure projects particularly so for international projects. Contingency sum (usually less than 5 per cent of construction cost relative to geographical area) in the construction cost estimate should be allowed for these uncertainties.

For instance, jetty developments within the Southeast Asia region often disrupt the livelihoods of fisher-
men and their fishing villages through: interruption of usual navigation route resulting in fishermen having to circumnavigate; threatening the sustainability of marine life; noise disturbances from pile driving works; traffic nuisance due to increase of construction vehicles; and creating aesthetic impacts which do not blend in with the surrounding landscape. When such events occur, negotiations between the project owner and the affected parties with the assistance of the local authorities should provide solutions that are mutually beneficial. Remedial actions can include monetary compensations for losses and interruptions, building alternate traffic routes, traffic planning and management, limiting pile driving activities to day time and installing navigational aids to prevent fishing trawlers from being too close to the construction area.

WHOLE LIFE COST

It is common for Quantity Surveyors to estimate first cost (capital cost) rather than calculating the life cycle cost for marine infrastructures because the former is relatively simple to estimate while the latter requires accurate maintenance expenditure data which can be difficult to obtain due to lack of well documented records. It is also difficult to justify a decision comprising a higher initial cost but with lower future costs due to uncertainties in the future operational needs of the structure. For example, during the design of a container terminal, it may be prudent to consider stronger beams for the ship-to-shore cranes in light of future increases in vessels’ beam length. However, due to the uncertainties in projecting future growth of vessel size, private port operators tend not to invest for a period beyond 10 years as viewed by PIANC (2008, p.48). It is interesting to note that a survey conducted by PIANC (2008) indicated that a high number of port operators do not view life cycle management (LCM) as providing positive assistance during planning stage but all the port operators had acknowledged that life cycle management is important.

While LCM can be adopted at every stage of a project, it is most beneficial to be done during the design stage as supported by Seah (2014) due to greater opportunities for change, lower cost of change and lesser resistance to change from the project team.

Without good maintenance cost data, an estimate based on percentage of construction cost can be adopted. Annual maintenance cost for jetties is usually taken to be circa 3 per cent of the overall cost of construction. Cost of maintenance dredging can be calculated based on estimated sedimentation rate, likely to be within a cycle of every 3 or 5 years.

Some examples of generally adopted LCM design parameters for a jetty include the following:
Some examples of LCM considerations when planning for a dredging framework include the following:

- Designing concrete cover to be at least 75mm;
- Concrete crack width limit state limited to between 0.1 – 0.3 mm;
- Use of pozzolans such as ground granulated blast furnace slag, fly ash and silica fume in concrete mixture;
- Substituting carbon steel reinforcing bars with stainless steel or glass fibre reinforced polymer;
- Cathodic protection (sacrificial anode or impressed current) for steel piles;
- Use of stainless steel or hot-dip galvanized with marine coating for cat walks, cat ladders, handrails and other steel works;
- Providing sufficient pile spacing to cater for future installation of additional piles; and
- Providing sufficient deck soffit clearance and pile spacing to allow maintenance inspection by boat.

CONCLUSION

The cost elements to be considered in the design of jetties and dredging as discussed in this paper are: size of vessel; dredging framework; length and span of trestle; comparison between caisson and deck on pile; ECI benefits; site characteristics; and whole life cost. The aforementioned cost considerations are not exhaustive; rather, it will provide Quantity Surveyors, Engineers and Project Managers with a structured plan in design optimisation process by narrowing onto key cost drivers.

While this paper examined cost considerations at a macro level, investigations on cost and benefit at a micro level will undoubtedly produce holistic cost estimates of marine infrastructures. This will include research on areas such as: comparison of fender types and brands; comparison of Quick Release Hook types and brands; statnamic load test versus static load test; spun piles versus steel piles; sacrificial anode versus impressed current cathodic protection systems; various dredger capabilities; and environmental management costs vis-à-vis geographical areas.

REFERENCES


Cost impact of the final disposal of construction residue in urbanization of slums by the Housing Department of the City of São Paulo

Guadalupe Araújo Yanguas

ABSTRACT

This work discusses an issue that in recent years has affected the cost of constructions managed by the Municipality of São Paulo: the lack of regulation of local and waste receiving fees Class II charged by receiving landfills, commonly called “bota-fora”. In 2002 the CONAMA 307 resolution was published, establishing guidelines, criteria and procedures for construction waste management. It has been determined by Article 5, which states that the municipalities and the Federal District should thereafter prepare the Integrated Plan for Waste Management of Construction. In this work, the adopted procedures will be presented. By contrast, in response to this resolution, final disposal sites were created and licensed waste, technically and environmentally, by CETESB. Unregulated, these places charge very different fees to each other, making it difficult to forecast spending on civil construction and impacting its cost significantly, especially in relation to earthworks and demolition. The lack of regulation, the discrepancies between these fees and the financial impact of these contracts in the Municipality of São Paulo will be the focus of this work, as well as proposals to mitigate the problem.

Keywords: Waste. Urbanization of slums. Cost. Transportation. Fee

INTRODUCTION

Nowadays, especially as a result of scientific developments, there is an accelerating growth of the world population. With this continuous increase, the consumption of natural resources also increases, as well as the generation of waste. The latter, due to the speed of its production, has not been able to be naturally reintegrated into the environment, generating a large volume of unused material.

Among all sectors of the world economy, Civil Construction is largely responsible for major changes in resources for the execution of large projects.

The mains characteristics of Construction Industry been summarized in the Waste Management Construction Notebook - Reduction, Reuse and Recycling developed in a joint project by SENAI, SEBRAE and the German GTZ, which is stated below:
• “One of the biggest sectors of the economy;
• Produces goods with the largest physical dimensions on the planet;
• Largest consumer of natural resources (20-50%), with the variants of consumption being:
  • The generated waste fee;
  • Lifetime or replacement of the structure;
  • The maintenance requirement;
  • The embedded losses;
  • The technology employed.”

To maintain competitiveness, the construction sector has recently been undergoing a restructuring process. For that, it is necessary to reduce the production cost and time of enterprises, reviewing business procedures, optimizing material consumption, and increasing labor productivity or even developing new technologies.

On July 5th, 2002, CONAMA (National Environment Council) issued Resolution 307, which entered into law on January 2th, 2003. This resolution is in respect to waste arising from construction renovation activities, repairs, demolition of structures and roads, general construction, removal of vegetation and soil excavation:

1) Classify them:
   • Class A: reusables or recyclables as aggregates;
   • Class B: recyclable for other destinations;
   • Class C: no technical or financial recyclability (e.g. plaster);
   • Class D: hazardous, such as inks, solvents, industrials, radiology clinics, among others.

2) Prioritize them in the following order:
   • no generation;
   • reduction;
   • reuse;
   • recycling;
   • final destination.

3) Requirements:
   • Generators: deployment and implementation of the Waste Construction Management Plan (PGRCC), which shall include procedures for characterization, sorting, packaging, transportation and disposal.
   • Municipalities and the Federal District: deployment and implementation of the Integrated Plan for Waste Management of Civil Construction (PIGRCC). This plan should include:
     I. technical guidelines and procedures for the Municipal Program of Waste Management and the PGRCC’s;
     II. registration of public or private areas suitable for receiving, sorting and temporary storage of
small volumes of small generators;

III. preparation of licensing procedures for areas of improvement and Disposal Waste Final (DFR);

IV. prohibition of unlicensed areas;

V. incentives for recycling or reuse;

VI. definition of transportation registration criteria;

VII. actions promoting fiscal orientation and accountability of the agents involved;

VIII. actions promoting educational activities.

In 2004, the Brazilian Association of Technical Standards (ABNT) has published standards related to Solid Waste Management, stated as follows:

- NBR 10004: 2004 -> classification of waste;
- NBR 15112: 2004 -> areas of shipment and screening (ATT);
- NBR 15113: 2004 -> landfills;
- NBR 15114: 2004 -> areas of recycling;
- NBR 15115: 2004 -> recycled aggregate in the execution of paving layers;

The NBR 10004: 2004 classification is used more than the one set by CONAMA Resolution 307.

This paper aims to point out the differences between the various “bota-fora” (waste landfill’s popular name) rates, the impacts of these fees on contracts of slum urbanization constructions of the Housing Department of the City of São Paulo (SEHAB / PMSP) and possible mitigating actions.

Slum urbanization constructions are normally interventions in areas of risk or which were unlawfully invaded. They are to be understood as risk areas near streams and in areas with slopes. The fact that they
are invaded illegally worsens the risk, a situation commonly encountered in these areas.

Thus, the work of the SEHAB, in addition to building housing units that meet the city demands, is trying to recover those areas to sustain these families in these places. It is done through plumbing of streams, geotechnical consolidation, earthworks, water distribution, sewage collection, drainage networks and paving, as well as the removal of irregular housing, and maintenance, recovery and regularization (sealing) of the remaining houses, which are not at risk.

**Figure 1** Pictures of Sapé slum in urbanization construction

**Source:** Consórcio Domus

**Figure 2** Picture of Paraisópolis slum in urbanization construction

**Source:** Consórcio Domus
The construction contracts cited are also managed by companies, which earned the bidding processes. These are mainly targeted assistance to the Department of Housing of this municipality in the supervision of construction jobs (services and measurements), project analysis and analysis of contract amendment requests (scope, time and cost).

In this study, the constructions used will be supervised by the Consórcio Domus, this consortium as such signed between the management firms Ductor Deployment Projects and ArcadisLogos. This management contract was signed in 2010.

The information presented was obtained from the compilation of studies and procedures developed by the Consortium Domus and adopted by SEHAB, regarding slum urbanization construction of the city of São Paulo.

The construction jobs used in this paper correspond to the following contracts:
Table 1 Works managed by Consórcio Domus

Source: Consórcio Domus. 2011

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract start</td>
<td>13/01/2010</td>
<td>01/04/2010</td>
<td>22/12/2010</td>
<td>20/10/2010</td>
<td>20/10/2010</td>
</tr>
<tr>
<td>Deadline</td>
<td>19/10/2010</td>
<td>30/06/2010</td>
<td>22/12/2012</td>
<td>20/10/2010</td>
<td>22/12/2012</td>
</tr>
</tbody>
</table>

DEVELOPMENT

Focusing on constructions of urbanization of slums contracted by SEHAB/PMSP through public bid, the base of this study are contracts signed in August 2010 and managed by Consórcio Domus. The contracts were the first to consider the remuneration of royalties, or fees on class IIA and IIB waste discharge by li-
licensed waste landfills by CETESB. The procedure adopted for the aforementioned contracts is unchanged until the present date by the entity.

It is important to remark that the values in this study do not present indirect benefits and expenses (BDI) and in the base date of the contracts, from August 2010.

The fees on Class IIA and IIB waste discharge were calculated based on wide market research. This research began with the request of indication of such waste landfills by CETESB, as well as field research. All the landfills were verified for the existence of operation license issued by CETESB, as well as their validity. The prices obtained (Annex I) show increased variation, proving impossible to treat them simply through market average or median for contractual approval. In addition, the cost of earth removal, the impacting item in the spreadsheet, presents average distance (DMT) between each construction site (generator) and receiving location. Therefore, in order to define the landfill for the final destination of residue, it is necessary to analyze the composite cost of the discharge fee and transportation of the material to be disposed of. Through this procedure, it is concluded that the choice of location will not ever be decided by the lowest fee value. The following table illustrates the situation:

**Table 2 Demonstration of the Lowest Cost Method**

<table>
<thead>
<tr>
<th>LOTE 11 - PARAISSIPOLIS</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Volume Class</strong></td>
<td><strong>IIA</strong></td>
<td><strong>474,723.01 m³</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Adress</strong></td>
<td><strong>Hebe Camargo Avenue, Paraisópolis, Morumbi, São Paulo</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Custo Unitário Transporte (contratual):</strong></td>
<td><strong>R$ 0,94/m³ x km</strong></td>
<td></td>
<td><strong>R$ 35,289,218,60</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site disposal of waste Classe IIB</th>
<th><strong>Adress</strong></th>
<th><strong>DMT</strong></th>
<th><strong>Fee (Atualização o jul/14)</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TECH LIX BOA HORA</strong></td>
<td><strong>Daniel Pedro Perelita Street, 925 - Sertãozinho - Mauá</strong></td>
<td><strong>39,63 km</strong></td>
<td><strong>R$ 37,04/m³</strong></td>
<td><strong>R$ 35,289,218,60</strong></td>
</tr>
<tr>
<td><strong>TERRITORIAL SÃO MATHEUS</strong></td>
<td><strong>Luis Matheus Avenue, nº1500 - Guararema, São Paulo</strong></td>
<td><strong>58,15 km</strong></td>
<td><strong>R$ 8,80/m³</strong></td>
<td><strong>R$ 30,126,366,94</strong></td>
</tr>
<tr>
<td><strong>ATERRO CTR GRAJAÚ (LUMINA)</strong></td>
<td><strong>Paulo Guiguerreimberg, Street, 3920 - Jd. Santa Tereza - São Paulo</strong></td>
<td><strong>28,00 km</strong></td>
<td><strong>R$ 22,23/m³</strong></td>
<td><strong>R$ 23,047,802,14</strong></td>
</tr>
<tr>
<td><strong>RIUMA AMBIENTAL (JUDICE)</strong></td>
<td><strong>Friedrich Von Volth Street nº1900, Conj. Pirituba - São Paulo</strong></td>
<td><strong>30,15 km</strong></td>
<td><strong>R$ 25,93/m³</strong></td>
<td><strong>R$ 26,441,130,25</strong></td>
</tr>
<tr>
<td><strong>ESSENCIS SOLUÇÕES AMBIENTAIS</strong></td>
<td><strong>Bandeirantes Highway Km 33 Cabelo Branco - Carceras SP</strong></td>
<td><strong>42,23 km</strong></td>
<td><strong>R$ 92,65/m³</strong></td>
<td><strong>R$ 62,827,786,43</strong></td>
</tr>
<tr>
<td><strong>TERRA FORTE SUIANO</strong></td>
<td><strong>Rio Abaixo, s/nº km, Suzano</strong></td>
<td><strong>70,50 km</strong></td>
<td><strong>R$ 12,34/m³</strong></td>
<td><strong>R$ 37,317,975,82</strong></td>
</tr>
<tr>
<td><strong>TERRA FORTE ITAQUAQUECETUBA</strong></td>
<td><strong>Estrada da Figueira Street, s/nº km, Rio Abaixo, Itaquaeceutuba</strong></td>
<td><strong>47,00 km</strong></td>
<td><strong>R$ 16,04/m³</strong></td>
<td><strong>R$ 28,587,819,66</strong></td>
</tr>
</tbody>
</table>

Information obtained from Annex 01
Table 2 shows the fees charged by each location of waste final disposition, the average distance to the construction site in question (Paraisópolis) and the expected quantity of waste to be disposed of. The price analysis of unit fee indicates that TERRITORIAL SÃO MATHEUS charges the lowest. However, when considering cost of transportation plus the fee, the lowest composite cost is ATERRO CTR GRAJAÚ (LUMINA), of R$ 23,047,802.14, a R$ 7,078,594.80 lower in comparison to TERRITORIAL SÃO MATHEUS that charges the smallest fee. As the analysis go on, the variation between the lower and bigger fee values correspond to more than ten times this amount. This is an important index of the consequence of lack of regulation of waste discharging fees.

Aiming to enhance the information presented here, each portion of this composition will be detailed in the following section, as well as the difference in the fees of each type of residue.

2.1 - Average Transportation Distance

As a consequence of the constant growing of distance between receiving locations of class II residue and the generator constructions, the major impact in total cost of the construction is the cost of the average transportation distance. This cost corresponds to at least 30%, getting all the way up to 86% composite cost (transportation plus fee) and to 15% of total cost of contract. Consider the following chart:

Figure 4 Chart transportation cost x total cost contract

Source: The Authoress

Projecting the near future, there will be an increasing impact on the transportation portion. This will happen especially as consequence of continuous growth and thickening of great urban centers and expansion of its fringe. The following map and chart illustrate the demographic growth in São Paulo. It shows the expansion and thickening that occurred in the city between 1880 and 2000.
In case of the city of São Paulo, the locations of materials destination are in the majority located in the outskirts of the metropolitan region, as seen in the following map:

**Figure 6 Areas for disposal of large volumes of construction waste – PMSP**

*Source: Management of waste from construction and demolition - Solutions for the Life Cycle, Élcio Duduchi Careli (2011)*
According to the previous map, the locations adopted in this study, licensed by CETESB, are identified as follows:

**Figure 7** Locais waste disposal Class II

**Source:** The Authoress

The increase in the average transportation system has been identified. It influences the official price lists published by SIURB (Department of Urban Infrastructure of the City Hall of São Paulo). In these, until the publication in January 2007, earth removal was considered in fifteen average distances (round trip) varying between 1,0km and 15,0km (Annex 2), being the latter the maximum distance. Comparing with the distances shown in Table 2, currently, the maximum of 15km considered correspond to 50% of the distance of the aforementioned construction site to the nearest aggregate landfill. In order to adequate to news landfill’s distances, SIURB started in July 2007 a publication to remunerate earth removal by m3 x km (Annex 3).

In May 10th 2007, through the Municipal Decree – SP n° 48.338, the circulation of trucks in the expanded downtown of São Paulo was regulated. In 2012 the Ordinances 123, 124 and 125 (Annex 4) classified Marginal Tietê, Marginal Pinheiros and Radial Leste and respective accesses as Restricted Structural Streets.
(RSL). These streets began to restrict traffic of trucks on certain days and times (defined in the Ordinances). However, constructions and services of urban infrastructure and concreting are presented in the aforementioned Ordinances as exceptions, having permission for circulation for longer periods than stipulated by the law. In order to be qualified as an exception, it is necessary to enroll the vehicles with CET. Therefore, the restriction does not impact the transportation cost of RCC's substantially. The following table shows the classification of restrictions and identification of streets.

2.2 - Fees on Final Disposition of Class IIB and IIA residue

The residue proceeding from civil construction works, RCC, are classified by the norm NBR 10.004:2004, specially as:

Residue class II A – Non-inert: residue that do not fit into the classifications of class I – Dangerous nor class II B – Inert. Can have properties such as: biodegradability, combustibility or water solubility.

Residue class II B – Inert: any residue that do not have any soluble constituent in concentrations higher than standards of water drinkability, except for aspect, color, turbidity, hardness and flavor (cf. Annex G).

2.2.1 Class IIB residue

Class IIB residue do not suffer any type of alteration in their composition with passing time. They do not generate gases and do not contaminate soil or water. In the context of the objects of the contracts studied here, residue proceeding from concrete demolition, steel, brickwork, ceramics and cementitious in general; also soil excavation residue, not necessarily of good geotechnical quality, but also with minimal levels of contamination by organic matter and rocks. This residue is disposed of in an aggregates' landfill, but they could be reutilized as paving sub base (NBR 15.115: 2004) and non-structural concrete aggregate (NBR 15.116: 2004).

The civil construction and aggregate landfill, or Class IIB (10.004:2004) or Class A (CONAMA Resolution 307/2002), is the area which aims to contain segregate material in order to enable the future use of the material or even the land. In this study the landfills apply more to the second option.

The implantation of the aggregate landfill must be approved in the local with the smallest possible environmental impact, approval by the neighboring population, and in respect to the legislation regarding environment and usage of soil. NBR 15113:2004 details compliances and requirements to pay heed to when the enterprise is implanted, including the necessity of the “Annotation of the Technical Responsibility” (ATR) of the project. It points out the necessity of analyzing the residue to be disposed of, as well as its origin and composition. In order to achieve this, in the item 7.6.a, the use of the Control of Residue Transportation (CRT) form is required.

The lands used for the implantation of landfills normally were areas in which mineral ores were explored. This happens because the 1988 Federal Constitution, 2º paragraph, article 225 requires the recuperation of the degraded area. This can be achieved through the remunerated reception of aggregated material, which results in economy with financial return for the party responsible for the enterprise.
2.2.2 Class IIA residue

On the other hand, Class IIA residue suffer reactions and liberate pollutants in the air, soil and water. Regarding the constructions analyzed here, Class IIA residue proceed from contaminated riverbeds and banks, and timber.

As a way to neutralize the impacts, the final disposition of this residue must be done in sanitary landfills. The implantation of these landfills must use devices that block contamination of soil and ground water, block the infiltration of gases and avoid explosions.

![Landfill scheme](http://www.ambsc.com.br/saiba-mais/residuos/)

**Figure 8 Landfill scheme**


The complexity of presented Class IIA residue treatment, added to the greater number of requirements made by CETESB regarding licensing and maintenance, results in reception rate of this type of residue being greater than the rate of Class IIB residue reception. As showed in the following chart, the reception rate of Class IIA material can get to up to three times the rate of aggregate material.
2.3 Fronts with greater discharge volume

In slum infrastructure constructions, which are the ones studied here, the service fronts that generate more residue are:

- **Earthwork**: the cutting and filling require the removal of excavated soil and providing of good soil (with adequate geotechnical conditions for the usage, clay for instance). The change is necessary because the soil is contaminated because of irregular occupation without minimal conditions of habitability. Another important factor is the regular proximity to water streams, whose sewage-polluted banks present a high concentration of organic matter.

- **Canalization of creeks**: as previously said, the soil excavated from river banks or beds, for the canalization work, will have pollutant traces; it is necessary to change the soil to sanitize the region and keep the integrity of the work.

- **Demolition**: removal of irregular houses in the intervention area. They generally are brickwork houses, with panels of wood, cardboard, concrete pieces and other materials, and roof slabs in panel, prefabricated slabs, CRFS or clay shingles.
The execution of habitational units also generates considerable residue. However, in the studied contracts, the cost of removal and final disposition of residue are remunerated by indirect benefits and expenses (BDI), under the local administration sub item that is levied over all the contractual spreadsheet and over the monthly measurement spreadsheets. This is why they are not considered in this study.

The constructions fronts regarding earthwork, demolition and canalization of creeks are coincidentally in the top of the ABC curve of the contracts. The following charts show this situation.

**Figure 10** Heliópolis Slum - Demolition for stream channeling and linear park

*Source:* Consórcio Domus 2005

![Heliópolis Slum - Demolition for stream channeling and linear park](image)

**Figure 15** ABC Curve and most significant services in final disposal rate costs

*Source:* the authoress
For the Lotes 04, 05 and 06, whose main contract object is the execution of habitational units, in partially occupied lands, the macro items corresponding to earthwork, demolition and canalization of creeks impact together in around 18% of the contracts. For the Lotes 11, 12 and 13, corresponding to the urban infrastructure constructions with irregular house removals and creek canalization, the impact gets up to 40%.

In the current analysis it is also necessary to verify the impact of these rates in each front, in relation to the total estimated in the contract.

The more recent contract additives were used in the making of the charts and tables in this study.
2.4 CETESB and SIGOR

When this work was being developed the CETESB published in its site the SIGOR: State System of Online Management of Solid Residue, instituted by State Decree n° 60.520 on June 5th 2014. As cited in the website http://cetesb.sp.gov.br/sigor/sobre-o-sigor/:

SIGOR is the tool that helps monitoring the management of solid waste since its generation through final destination, including transportation and intermediary destinations. It allows the management of information regarding the stream of solid residue in the State of São Paulo.

In the same website CETESB presents the Civil Construction Module, that it aims to manage the information regarding the stream of civil construction residue in the State of São Paulo, since its generation through final destination, including transportation. Its correct utilization ensure that the residue is transported by legalized companies and destined to legalized places, allowing for the adequate environmental destination of residue.

2.5 – SEHAB and mitigation actions for high cost of transportation and final disposal of materials

As a way to minimize not only the costs of residue destination but also the environmental impact of its works, SEHAB should invest in better Environmental Management, implanting such solutions as:

1. Requiring in contracts the recycling of class IIB material and its reutilization as aggregate in non-structural concrete, or even as base for paving.

2. Anticipating in the reference spreadsheet the place for drying the material from the excavation stream prior to removal to the landfill wet material, proceeding from creeks, that cannot be transported wet.

3. Anticipating in the reference spreadsheet the area of separation of material proceeding from demolition, optimizing reutilization:
   - In the moment of decharacterization (the first moment of demolition, in which not all families were removed yet, but the place must be decharacterized to avoid reinvasion): removal and possible donation of sashes, doors, toilet bowls, sinks and metal faucets.
   - After the demolition: removal from the debris of all material that characterizes as Class IIA. Reutilize or send to adequate licensed receiving location.
   - Class IIB material must be sent to the area of separation for sorting.

4. It must be requested a certificate of recycled material usage in non-structural concrete, service roads of the construction site, material for stabilization of the land, base for paving, among others.

5. Anticipating reimbursement for recycling of Class IIB material as a fee payed for the spreadsheet with no revenue incidence.

6. In order to illustrate the results of the proposal, the following table was drawn with the estimates of
The economy resulting from recycling of Class IIB residue. The data regarding services, values and quantities utilized in the calculation were obtained from the Paraisópolis contract.

3 - CONCLUSION

Given the facts presented in the previous chapter, it is clear the importance of regulation and control of the fees charged by waste landfills and how much the costs involved directly impact the total value of contracts. The responsibilities of townships to produce a management plan to control civil construction waste landfills are presented. In the plans produced until now there are no regulations concerning the control of discharge rate.

For the SEHAB, whose constructions are the object of this study, there could be an internal discussion, along with other Departments, to define this regulation.

Adopting the procedures and arrangements described above, savings in construction costs are expected, as well as better managing of the environment. It is important to emphasize that, with respect to SEHAB responsibilities, the economy referred to here will be obtained by control of residue generation. In case of better management of receiving locations, as well as regulation of fees charged by CETESB or other competent bodies, savings can be even higher, allowing for investment of money saved into other more necessary enterprises for the people of São Paulo.

REFERENCES


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______. Photography of Favela Heliópolis. 2007. 1 photography.

______. Photography of Favela do Sapé em obras de urbanização. 2011. 3 photographs.

______. Photography da Favela Paraisópolis e seu adensamento. 2012. 2 photographs.

______. Photography da Favela Paraisópolis em obras de urbanização. 2012. 2 photographs.

______. Local waste disposal Class II the Consortium Domus. 2014. 1 figure.

______. Map of location of the works of SEHAB managed by the Consortium Domus. 2010. 1 figure.

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LIMA, Rosimeire Suzuki; LIMA, Ruy Reynaldo Rosa. Guide to Construction Waste Management Project Development. CREA-PR.


SECRETARIA MUNICIPAL DE TRANSPORTES. Portaria nº123/12. It provides for transit trucks in Marginal Tiete and other City of roads and establishes its exceptionalities.

______. Portaria nº124/12. It regulates the truck traffic on the Marginal Pinheiros, Av. Dos Bandeirantes and other City of routes and sets their exceptionalities.

______. Portaria nº125/12. It regulates the traffic of trucks on the roads that make up the Radial Leste axis and establishes its exceptionalities.

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ATTACHMENTS

Attachment 1 – Prices obtained for receiving construction waste rates
Tabela de Taxas de Disposição final de Resíduos de Construção Civil Classe IB - Inseres

<table>
<thead>
<tr>
<th>LEVE NOBRE</th>
<th>DURMOISO</th>
<th>PEDRERIA</th>
<th>ATERRO CITRAL</th>
<th>BRAMA SOBRE</th>
<th>ESSENCES</th>
<th>TERRA FONTE</th>
<th>JECOBIBA</th>
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</table>

Data: 01/01/2015
Contacto: José H.

Taxa de Disposição Classe IB a partir de 01/01/2015

<table>
<thead>
<tr>
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Taxa de Descarrego

<table>
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<th>Unitário</th>
</tr>
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<tbody>
<tr>
<td>Classe IB</td>
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</tr>
</tbody>
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Composição do Custo de Descarrego em Bota-Fora com o Volume do Transporte

Gás:

<table>
<thead>
<tr>
<th>Volume m³</th>
<th>Custo R$</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Distância de Transporte (a ser estabelecida para a implementação):

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<thead>
<tr>
<th>Distância Km</th>
<th>Custo R$</th>
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</thead>
<tbody>
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Taxa para a Implementação do Rodízio de Empreendimentos (Composto no Bota-Fora):

<table>
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<tr>
<th>Taxa R$/m³</th>
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<tbody>
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Indices e fatores de conversão:

1. Fator de Emissão

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2. Básico Específico de Emissão (bão para o reloco)
### Cotação doTaxa de Disposição final do resíduos de construção civil Classe III - Brotas

**Descrição**

<table>
<thead>
<tr>
<th>CPF/CNPJ</th>
<th>Nome</th>
<th>Endereço</th>
<th>Telefone</th>
<th>Telefax</th>
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<tbody>
<tr>
<td>12345678-90</td>
<td>Domus Construções Ltda</td>
<td>Rua遵义, 123 Brotas</td>
<td>(11) 987654321</td>
<td>(11) 98765432</td>
</tr>
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**TAXA DE DEPOSIÇÃO FINAL CLASSE III (TABELA 2010)**

<table>
<thead>
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<th>Válido até</th>
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<th>Válido até</th>
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<tr>
<td>01/01/2010</td>
<td>R$30,00/m3</td>
<td>31/12/2010</td>
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<td>R$40,00/m3</td>
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<tr>
<td>01/01/2011</td>
<td>R$40,00/m3</td>
<td>31/12/2011</td>
<td>R$45,00/m3</td>
<td>31/12/2012</td>
<td>R$50,00/m3</td>
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<td>01/01/2014</td>
<td>R$70,00/m3</td>
<td>31/12/2014</td>
<td>R$75,00/m3</td>
<td>31/12/2015</td>
<td>R$80,00/m3</td>
<td>31/12/2016</td>
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</table>

**Composição CUSTO DE DESCARREG EM BOTA DO com o Volume de Transporte**

A composição custo de descarregamento em bota fora do volume de transporte é calculado para a taxa efetiva por m³ e o número de viagens necessárias para o transporte de resíduos.

<table>
<thead>
<tr>
<th>Detalhes</th>
<th>Custo por m³</th>
<th>Custo por viagem</th>
<th>Custo por km</th>
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</thead>
<tbody>
<tr>
<td>Estimativa tarifa por m³</td>
<td>R$30,00/m³</td>
<td>R$35,00/m³</td>
<td>R$40,00/m³</td>
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<tr>
<td>Custo total de transporte (a ser pactuado)</td>
<td>R$20,00/m³</td>
<td>R$25,00/m³</td>
<td>R$30,00/m³</td>
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<tr>
<td>Taxa de retenção do transporte e descarregamento</td>
<td>R$15,00/m³</td>
<td>R$20,00/m³</td>
<td>R$25,00/m³</td>
</tr>
</tbody>
</table>

**Indices e Atualizações**

1. **Índice de Preços:**
   - **Índice de出去:** 123.45
   - **Taxa de inflação:** 6.78% por ano

2. **Variação de preço:**
   - **Índice:** 123.45
   - **Variação por ano:** 6.78%
Cotação de Taxa de Disposição final de resíduos de construção civil Classe III - Intes

<table>
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<td>TAXA DE DISPOSIÇÃO final Classe III em terra dura</td>
<td>R$2,01,00/m³</td>
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<tr>
<td>TAXA DE DISPOSIÇÃO final Classe III em subaquático</td>
<td>R$2,01,00/m³</td>
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<tr>
<td>TAXA DE DISPOSIÇÃO final Classe III em subaquático</td>
<td>R$2,01,00/m³</td>
</tr>
<tr>
<td>VALOR CORRIDO PARA INCIDÊNCIA DE 1% em 15%</td>
<td>R$2,01,00/m³</td>
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</table>

Composição Custo de Descarga Embarcação com o Volume de Trampante

A escolha do bote-buque mais econômico deve ser levada em consideração, considerando a contratação de limpeza de material, a distância média de transporte de obra em questão e o volume do bote-buque.

<table>
<thead>
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<th>Material</th>
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<tr>
<td>R$27,04/m³</td>
<td>R$22,20/m³</td>
<td>R$22,20/m³</td>
</tr>
<tr>
<td>R$25,90/m³</td>
<td>R$25,90/m³</td>
<td>R$25,90/m³</td>
</tr>
<tr>
<td>R$32,25/m³</td>
<td>R$32,25/m³</td>
<td>R$32,25/m³</td>
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Distância média de transporte em quilômetros (km):

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<th>Distância Media de Transporte</th>
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<tbody>
<tr>
<td>33823</td>
<td>39,15</td>
<td>28,00</td>
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Descrição: (c) 2016 DOMUS CONSÓRCIO DE TECNOLOGIA E INFORMÁTICA LTDA.
<table>
<thead>
<tr>
<th>Título</th>
<th>Autor</th>
<th>Localização</th>
<th>Data</th>
<th>Duracao (horas)</th>
<th>Resumo</th>
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<tr>
<td>Título 1</td>
<td>Autor 1</td>
<td>Localização 1</td>
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<td>2</td>
<td>Resumo 1</td>
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<tr>
<td>Título 2</td>
<td>Autor 2</td>
<td>Localização 2</td>
<td>Data 2</td>
<td>3</td>
<td>Resumo 2</td>
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</table>
## Tabela de Custos Unitários de Infra-Estrutura

**Data Base: JAN/2007**

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<td>Securidade Executiva</td>
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<tr>
<td>02-50-00</td>
<td>Desenvolvimento de Topografia</td>
<td>H</td>
<td>18,79</td>
</tr>
<tr>
<td>02-51-00</td>
<td>Auxiliar Técnico em Pavimentação (Nível Médio)</td>
<td>H</td>
<td>11,54</td>
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<tr>
<td>02-52-00</td>
<td>Serviço de Plotagem em Papel Sulfite - Tam. A1 - Preto e Branco</td>
<td>UN</td>
<td>4,80</td>
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<tr>
<td>02-52-01</td>
<td>Plotagem em Papel Sulfite - Tam. A1 - Color</td>
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<tr>
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<tr>
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### Movimento de Terra

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<th>Custo Unitário R$</th>
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<td>04-01-00</td>
<td>Excavação Manual para Fundações e Valas com Profundidade Média Menor ou Igual à 1,50 M</td>
<td>M3</td>
<td>18,83</td>
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<tr>
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<tr>
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<td>M3</td>
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<tr>
<td>04-04-00</td>
<td>Escavação Manual para Fundações e Valas com Profundidade Média Maior que 5,00 M</td>
<td>M3</td>
<td>31,38</td>
</tr>
<tr>
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<td>Excavação Mecânica, Carga e Remoção de terra até a distância média de 1,00 KM</td>
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<td>6,52</td>
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<tr>
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<tr>
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### Assessoria de Custos
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<th>CUSTO</th>
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<td>03-52-01</td>
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<td>04-00-06</td>
<td>MOVIMENTO DE TERRA</td>
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International Measurement Standards: 
Space, Cost and Technology

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ABSTRACT

Purpose

This paper examines the emerging need for unified and harmonized international standards in the built environment, infrastructure and energy sectors to measure, classify and cost projects to improve industry performance in these sectors. It highlights the needs for these standards to incorporate rapidly developing digital technologies in fields such as Building Information Modelling (BIM), Big Data and Smart Cities. Technology needs professional standards and, in terms of data collection, use of predictive data and general relevance, professional standards need technology. As the implementation of BIM and other digital technologies continues to grow the need to develop international professional standards becomes ever greater.

This paper commences with an analysis of how decisions are currently typically made through the project life cycle and proposes that improving project performance is only possible by improving decision-making at each stage of the project life cycle and that decision making can only be improved by providing the right information, in the right form, at the right time. It then examines the key technological changes that are occurring in the industry and how this is likely to develop to support such decision-making. The need for international standards to further support this are explored and an industry perspective is provided from the energy sector. Two current industry initiatives being developed to address this need are then described – the International Property Measurement Standard (IPMS) and the International Construction Measurement Standard (ICMS).

Research Methodology

The research methodology is based on a review of global industry literature and data on project decision making, digital technologies and international standards, an industry perspective from the energy sector and two case examples of international measurement standards that are currently being developed.
Findings, Value & Practical Implications

The key findings of the paper are that development of international standards such as the IPMS and ICMS will help to provide essential global classifications to allow more consistent global approaches to using project data generally and the data/information available through BIM/Big Data/Smart Cities technologies. As BIM, Big Data and Smart Cities begin to merge as concepts, standard classifications will assume an even more important role in order to make sense of the deluge of data. This will provide enormous benefit for all industry players at all levels – project, national and international.

Keywords:
Measurement Standards, Construction, Infrastructure.

1 INTRODUCTION

Cultural change and technological innovation are axiomatic. In the built environment, Building Information Modelling (BIM) and ‘big data’ promise much, but they have to overcome global industry challenges and fragmentation.

Various studies have shown that improving project performance is only possible by improving decision-making at each stage of the project life cycle. In turn, decision-making can only be improved by providing the right information, in the right form, at the right time. Hence, developing standards for this information is crucial. Of course, we need open data standards at an Information Technology (IT) technical level. In addition, however, we also need standards for the professional work processes for those populating the BIM model(s).

However, information is like turning on a fire hose. It can quickly overwhelm you. It therefore needs to be defined in accordance with what decisions need to be made at each stage of the project lifecycle. Defining information needs is critical.

Technology needs professional standards - and, in terms of data collection, use of predictive data and general relevance, professional standards need technology. So, as BIM advances and the disruptive technologies affect property and construction, the need for international professional standards becomes ever greater.

This paper considers how decisions are currently typically made through the project life cycle, the technological change that is upon us and how this is likely to develop to support decision-making. It then looks at the emerging need for unified and harmonized international standards to further improve industry performance and provides an industry perspective from the energy sector. In short, it considers how technology improvements and standards together can be transformational.
2 DECISION MAKING IN CONSTRUCTION

2.1 Decision Making Generally

Decision making has always been a major topic of research in the field of the management of construction. Recent trends (such as the push for sustainability, the increased desire for public engagement, and the globalization in construction) have influenced the environment under which decision-makers work. Consequently, the models of how decisions are formed and made should adapt to that change. Decision criteria have evolved from focusing on the technical and objective to soft and subjective aspects of construction. A general migration from models with pure deterministic nature to (fundamentally) probabilistic models with stochastic approaches is noted. The complexity of engineering problems has resulted in a shift from judgmental to rational selection techniques. Interest in softer and subjective issues (such as sustainability) and the increasing number of (diversified) stakeholders have promoted the application of emergent-based selection methods, particularly in infrastructure projects. These changes suggest a trend for more focus on technological development and networks, managing the evolutionary (and possibly, chaotic) process, and harnessing collective intelligence of users to generate innovative solutions.

Decision-making in construction projects involves the management of multiple interrelated components such as quality, space, time, and cost. Uncertainty associated with each of these parameters, and the evolving relationships between them within the constraints of time, cost and space are at the root of complexity in project management. Accounting for this complexity is critical to effectively plan for contingencies and test the usefulness of alternative decision-making strategies. However, predicting the consequences resulting from such complex behaviour is difficult as they are often emerging within dynamic contexts.

2.1 Decision Making Gateways

A simple way to avoid making the wrong decisions at the wrong time is by establishing a series of project gateways at which the project team compile information describing the project as it stands, the client assesses that information and either asks for changes or approves it and gives instructions to progress to the next stage.

At each of these stages, certain aspects of the project may be ‘frozen’ and change control procedures introduced for those aspects. For example, at the end of the concept design stage, the project brief may be ‘frozen’. Freezing the project brief means that it can only be changed with the explicit agreement of the client, and then only when the cost implications and the disruption of the change have been evaluated and accepted, and the change recorded.

By adopting a process of progressively reviewing and approving aspects of the project, it moves forward in a controlled way. If this strategy is not adopted, the client and project team can lose focus, uncertain of what has been decided and what has not and unable to make progress. There can also be ‘scope creep’ where instructions are given without a proper assessment of whether the instructed work is included in existing fees, whether it has been authorized, or whether it is a sensible use of the clients funds.
2.3 Decision Making & Building Information Modelling

Building Information Modelling (BIM) is a very broad term that describes the process of creating and managing digital information about a building or other facility (such as a bridge, highway, tunnel and so on). It can substantially aid this staged decision-making process.

To ensure projects are properly validated and controlled as they develop, data is extracted from the evolving building information model and submitted to the client at key milestones. This submission of data is described as a 'data drop' or 'information exchange'.

Generally, data drops are aligned to the project stages described above, and the information required reflects the level of development that the project should have reached by that stage. This might be considered analogous a stage report on a conventional project.

The nature of data drops should be set out in a set of requirements at the beginning of a project. These requirements may be considered to sit alongside the project brief. Whilst the project brief defines the nature of the built asset that the employer wishes to procure, the requirements define information about the built asset that the employer wishes to procure to ensure that the design is developed in accordance with their needs and that they are able to operate the completed development effectively and efficiently.

Data drops are likely to include:

- Models (Industry Foundation Classes (IFC) models and native project information models).
- Data structures (such as COBie files and schedules).
- Reports (typically PDF’s, although native files can be more useable).

The client will check the data in terms of compliance with the requirements, compliance with the brief, space, cost and so on before deciding whether the project should proceed to the next stage.

The timing and exact requirements for data drops will vary with the nature of the project and the needs of the client, however, typically it includes the following stages:

1. Brief  
2. Concept  
3. Definition  
4. Design  
5. Build & commission  
6. Handover & closeout  
7. Operation & in use

There may also be information exchanges within the supply chain, which may be more frequent than employer information exchanges.

3 TECHNOLOGICAL CHANGE
3.1 Building Information Modelling (BIM)

BIM and its allied digital technologies and tools provide enormous opportunities for project cost management professionals to dramatically improve the quality, speed, accuracy, value and sophistication of their cost management services and therein ensure their future as key players in the BIM world. This is particularly the case during the design development stages when various design options are being proposed and evaluated. The ability of the project cost manager to use BIM models and other digital technologies to provide quick and accurate cost advice throughout the design simulation process provides an enormous opportunity for the profession to play a key leading role in sustainable design and construction development. Muzvimwe (2011) supports this notion and describes the value of the cost manager in being able to simulate and explore various design and construction scenarios for the client in real time through having their cost data and quantities integrally linked in the live BIM model. This certainly raises the value of the cost management service but is dependent on the cost manager having BIM capability/expertise, sharing their cost data in the model and having the experience, expertise and intuition to analyse and critique the information that is being generated by the model.

RICS (2014) contend that BIM provides project cost managers with the opportunity to spend more time on providing knowledge and expertise intensive advice to the project team - the automation of processes such as quantification will substantially reduce time spent on technical processes and will provide more time and the digital tools for higher value-added and more sophisticated cost management services.

However, the lack of global standards in relation to BIM measurement creates a range of issues and problems for the project cost management profession. The automated quantities generated from the range of software programs utilised in BIM platforms vary widely in terms of format and content. Tremendous benefits could be obtained if international BIM measurement standards were developed by the profession and software authors influenced to adopt these standards.

In the UK, initiatives towards consistent standards for BIM models have begun. In 2012 the RICS published new guidelines known as the Black Book (Quantity Surveyor and Construction Standards) and New Rules of Measurement (NRM). The Black Book is a comprehensive suite of documents that defines good technical standards for Quantity Surveying and Construction in the UK. The New Rules of Measurement suite provides a common measurement standard for cost comparison through the life cycle of cost management. “The suite has been developed as a result of industry collaboration to ensure that at any point in a building’s life there will be a set of consistent rules for measuring and capturing cost data, thereby completing the cost management life cycle and supporting the procurement of construction projects from cradle to grave. A better understanding of costs during the construction process will increase certainty for business planning and support a reduction in spending on public and private sector construction projects in the long run” (Property Wire 2012, p.1). The UK accelerative BIM mandate recognised these standards in developing consistent cost applications in BIM models.

The New Rules of Measurement are integrally linked with BIM and enables a consistent approach to estimating and cost planning within BIM platforms. The RICS have also recognized the need for global guidance for companies in terms of BIM implementation. They recently published a comprehensive ‘International BIM Implementation Guide’ for construction professionals and contractors that includes
specific guidance for project cost managers (RICS 2014). They note that “as the industry takes hold of this new future it is essential that organisations and individuals are not flying blind but have information to plot out a change plan and BIM implementation trajectory both for now and indeed a ‘future wise’ longer term digital strategy” (RICS 2014, p.1).

The project cost manager also has an important role to play in the measurement and costing of the operational and environmental performance of buildings. The Global Alliance for Buildings and Construction (GABC 2015, p. 8) note that “Measurable, Reportable and Verifiable (MRV) information is pivotal to accelerating energy-efficiency in the buildings and construction sectors. In order to finance, construct, and renovate low-carbon, sustainable buildings, decision-makers in the building sector require high quality data to drive, motivate, finance, and require prudent policy action. At present, despite increasingly globalized building and construction markets, measurement and evaluation tools to track and monitor building performance, continue to vary considerably across the globe. However, it is important to calculate the energy savings’ multiple benefits, also towards the local market”.

The lack of consistent measurable data provides opportunities for the project cost management profession to address this issue and become key players in the measurement and analysis of building operational performance. The GABC (2015, p. 8) stress that “transparency and comparability rely on consistent data. Yet the way buildings are currently measured varies dramatically, this significant variability introduces high uncertainty in valuation and project-cost estimation”. They highlight the need for the development of “international standardized and vertically integrated (inter-governmental) measurement and reporting to enhance the understanding and international comparison of energy efficiency data and relevant resource flows for reduced GHG emissions” and the “development of international data, measurement, and standards” in the built environment sector.

3.2 Big Data

Big Data is revolutionising 21st century business generally and is opening up significant opportunities in the construction industry to deliver better ‘value-added’ projects more effectively, efficiently and sustainably. Whilst a wide range of definitions have been developed to describe big data, the basic concept is that the rapid development of the internet and digital technologies over the past two decades has meant that what people do is increasingly leaving a digital trace (or data) which can be used and analyse. Big data therefore refers to that enormous amount of data that can now be collected and the ability to make use of it. The big data trend will continue to grow at a rapid rate as the digital tools required to collect and analyse the data are become more powerful, less expensive, more accessible and easier to use.

Another terminology used is the ‘Internet of Things’. Mitchell (2015, p.1) contends that “the Internet of Things – the linking of physical objects with embedded sensors – is being developed at a breakneck speed. Companies and consumers are now using technology daily to track movements, improve collaboration and customer service to increase productivity at an organisational and personal level. This simultaneously creates massive network effects and opportunities for global industries to shape our lives”.

Whilst slow to embrace the use of big data compared to many other industries, the impact of bid data on the construction industry will be enormous. Marr (2016, p.1) notes that “huge amounts of resources and
work go into major construction projects and of course this means that huge volumes of data are generated. Number crunching has always been a big part of construction – a commonly heard phrase is that construction companies are accounting companies which happen to erect buildings. It’s an industry where 35% of costs are accounted for by material waste and remedial work. So counting the cost of every screw could be the difference between delivering on budget and bankrupting an organization (or several organizations) financing a build”.

Whilst analytics have always been used in the construction, the effective utilisation of big data will require more advanced analytics and investigation. “Construction firms are now starting to move into real-time cloud-powered analytics of large and unstructured datasets (which) have the potential to redefine the traditionally fraught relationships between the interested parties” (Marr 2016, p.1).

High level analytics are likely to increasingly drive planning and design strategies as well as post occupancy evaluations. Mitchell (2015, p.1) provides an insight into the future. “Building-occupant research has long played a critical role in planning for some projects. What’s changing is the immediacy and sheer amount of data, and the ease by which it can be collected and analysed. The retail supermarket sector is emblematic of living, breathing and using data to track customer behaviour and applying these metrics to benefit the future design and fit out of stores. Additionally, the rise of mobile devices and social media, coupled with the use of advanced survey tools and interactive mapping apps, has created a powerful conduit through which building teams can capture real-time data on the public — what spaces they like most and least in a given building, where they prefer to hang out on campus, whether they take public transportation or drive to work. With advanced traffic flow simulation programs that allow users to program thousands of avatars with unique behavioural characteristics, building teams can predict—with a much higher degree of certainty—how people will interact with a space layout”.

3.3 Smart Cities

Big data analytics are being used as part of the global trend towards ‘Smart Cities’. Other terminologies used include ‘Intelligent Cities’ or ‘Digital Cities’. The basic concept is that the better use of the internet, digital technologies and big data can help cities to develop more effectively, provide better services and operate in a more sustainable manner.

Zistl (2016) cites current research that shows that by 2030 60% of the world’s population will live in urban centres and that by 2050 this will increase to 70%. He cites the problem that cities already account for 70% of global greenhouse emissions and that 90% of current urban residents live in cities with pollutant emissions above recommended thresholds. “Many cities are already struggling with a shortage of living space, overburdened infrastructure, and vulnerable water and energy supplies. There is also an increasing risk of natural disasters caused by climate change — which is made significantly worse by the emissions of large cities” (Zistl 2016, p.1).

Cities are now looking to the digital age to address these problems – in effect, cities operating like large computers. “Over the past decade digital technologies have begun to blanket our cities, forming the backbone of a large, intelligent infrastructure. Cities are quickly becoming like computers in open air” (Ratti 2015). They are becoming smart by the use of big data and sophisticated digital technologies. The chal-
The challenge is to transform the enormous amounts of digital data increasingly being generated into actionable knowledge.

Clarke (2015) notes that there has been a marked increase in the awareness and, in part, adoption of the Smart City concept by various levels of government agencies around the world. However, Clarke cites the increasing need for Smart City strategy development and implementation road maps for these agencies. She predicts that by 2017, at least 20 of the world’s largest countries will create national smart city policies to prioritise funding and to document technical and business guidelines. Nevertheless, she contends that the lack of global strategies and implementation guidelines will inhibit ‘Smart City’ development on a global scale.

The Smart City trend will continue to grow and provide enormous opportunities and challenges for professionals in the construction industry. This is likely to open up completely new markets for technologies and services. Zistl (2016, p.1) provides an insight into the future. “The future of smart cities will be shaped by the Internet of Things as a networking technology and by smart data as a forecasting technology. For example, power generation and consumption can be coordinated more precisely when consumers such as air conditioning systems can be automatically dialled down during periods of peak demand; increasing decentralization of power generation can be managed efficiently through implementation of smart grid technologies; and industrial facilities, buildings, and transportation systems can be integrated as energy service providers”.

4 INTERNATIONAL STANDARDS

4.1 International Business Practice & Standards

Business practices are increasingly demanding global rules. This is required in the accounting arena, with international financial accounting standards. With 70% of global wealth in land and property, measurement of space in property and standards in construction cost are prime candidates.

Global standards also enable better project decision-making using BIM, as described above, to be more consistently applied in different markets, leading to greater capability for benchmarking and greater transparency.

4.2 International Property Measurement Standards (IPMS)

International Property Measurement Standards (IPMS 2016) have already been established as a coalition of bodies to agree, sector by sector, international standards for floor areas used in valuation, property management and construction. At present, the way property assets – such as homes, offices or shopping centres – are measured varies dramatically. For example, in some parts of the world it is established practice to include common space (lift shafts; communal hallways etc) in floor area measurements; in others off-site parking might be included or even swimming pools. With so many different methods of measurement in use, it makes it difficult for property users, investors, occupiers and developers to accurately compare space. Research by global property firm JLL shows that, depending on the method used, a property’s floor area can deviate by as much as 24%.
The International Property Measurement Standards Coalition (IPMSC) is an international group of professional and not-for-profit organizations working together to develop and embed a single property measurement standard. This now constitutes more than 60 organizations. IPMS for residential has also recently been published for consultation. The international measurement standard principles will integrate with detailed measurement standards in accordance with local market jurisdictions, to ensure that standards are adopted bottom up. These will be developed in consultation with expert, international practitioners and panels, subject to international consultation and stakeholder review. All this will improve certainty in construction and enhance project performance for the users of the industry. This, we believe, is central to the mission of a professional body.

4.3 International Construction Cost Comparisons

Similarly, there are difficulties in comparing the cost of construction projects on an international basis. Surveys carried out by the RICS and the European Council of Construction Economists (CEEC) of cost consultants in 40 countries have shown that:

- approximately 50% of countries did not claim any published standard elemental classification of building parts
- in the absence of locally agreed standards, professionals frequently adopt ‘foreign’ standards or ad hoc in-house developed standards
- there is no common way of expressing cost per m², both in terms of the cost definition and the floor area
- there are many countries where the quality of cost information and data classification falls short of what local professionals might wish (BCIS 2009).

BCIS (2009, p.4) concluded in its survey: “Although there are countries with quite complete cost related standards and information sources, there appear to be many more where the quality of published guidance and cost information falls short of what local professionals might wish”.

4.4 International Construction Measurement Standard (ICMS)

Accordingly, more than 30 professional bodies from around the world met at the beginning of June 2015 at the International Monetary Fund in Washington DC to launch the International Construction Measurement Standards (ICMS). The ICMS Coalition was established by non-profit organizations representing professionals in more than 140 countries. Collectively, the group aims to harmonize cost, classification and measurement definitions to enhance comparability, consistency, statistics, and benchmarking of capital projects.

Inevitably, the coalition will continue to grow as further professional organizations come forward. Industry corporations, contractors and key government stakeholders are encouraged to contribute to, and lead adoption of, the new international framework in their capital markets. Work is already underway by
an independent committee of construction experts, appointed by the coalition. Indeed, the Washington meeting represented a landmark moment for the construction, project management, cost engineering and quantity surveying sectors as a whole. This is the first time these professions have come together in this way to develop unifying standards that reflect and enhance the increasingly international construction market.

4.5 Current Progress

Progress with these two projects has been impressive.

IPMS office buildings was published in November 2014, whilst IPMS residential buildings has been through two consultation processes, both as a consultation document and as an exposure draft, and is due to publish in July/August 2016. IPMS 3 – industrial buildings went into consultation on Tuesday 5th July 2016 and the Consultation process closes on Friday 30th September 2016. The IPMS SSC are now hard at work on beginning to draft the consultation document for IPMS – retail buildings, which should go into consultation in 2017. Once this work has been completed, the SSC will be harmonising the IPMS standards and definitions across all building classes and will also begin work on IPMS for mixed used properties and specialist properties such as hotels, hospitals and schools.

ICMS will go out for public consultation in November 2016, and is on track to publish in 2017. Before the public consultation, ICMS will undertake a ‘Friends and Family’ consultation (comprising governments, NGO’s and business partners) to ensure that market feedback has been incorporated into the public draft.

IPMS and ICMS relate to each other as essential global benchmarking data classifications. Buildings are often compared and analysed on a cost per unit of measurement basis (per square metre or square foot) and therefore, used together, these standards remove inconsistencies and opaqueness from international comparisons.

5 AN INDUSTRY PERSPECTIVE – THE NEED FOR MEASUREMENT STANDARDS

5.1 Industry/Societal Needs

Future energy demand of smart cities will be radically different from current experience. Technology and big data are taking driverless cars, smart electricity grids, from a possibility to a reality. There are alternate energy sources, new extraction techniques versus conventional plays, enhanced recovery maintenance technologies, the shifting balance from oil to gas, against a framework of increasing regulatory and compliance requirements. This coupled with the increasingly efficient production of energy is leading to a rapidly changing human ecosystem. To attain low cost and maintain profitability the industry has leveraged low cost engineering, and manufacturing centres. The traditional linear scheduling techniques are being replaced by a production process with multiple activities occurring in parallel. New techniques are relying on big data as the future for project management platforms. Without standards a base cannot be established for measurement with cost and schedule outcomes remaining unpredictable.
The intent of the International Construction Measurement Standard (ICMS) is to produce an International Standard that is equally applicable to stakeholders across many industries. The initial focus on infrastructure addresses the problem from two perspectives - the needs of society with the exponential growth in smart cities and associated demand on GDP, and also the drive for sustainability in the execution and operational phases of all projects.

5.2 Industry Problems – Oil & Gas Industry Examples/Comparisons

At this point reference to the Oil & Gas Industry will help illustrate the universal problems faced by the ‘property’ industry, and the convergence of project lifecycles brought by the advent of BIM and related technologies. The reasons for this perceived industry convergence are emanating from the need for greater predictability developing executing and operating, sustainable assets, the increased globalization of energy resources, and technology where 5D applications are a minimum, whether it is BIM, PDMS, or other similar technology.

Oil & Gas mega projects have struggled to be delivered on time and budget. Based on extensive industry research and practice, Morrow (2011, p. 1) found that “over half of large-scale engineering and construction projects - off-shore oil platforms, chemical plants, metals processing, dams, and similar projects - have miserably poor results. These include billions of dollars in overruns, long delays in design and construction, and poor operability once finally completed”. The Construction Industry Institute (1996 & 1998) reported that early estimates of industrial projects can differ by as much as 100-250% compared to the actual end project cost and that even well executed and detailed estimates can differ by up to 25%.

Infrastructure projects by definition are usually mega projects and face similar challenges to project delivery. These challenges will be further at risk through the lack of consistent reliable measurement data to support decision making.

Similar to the process described above, the execution model in Oil & Gas Industry has been a typical phase gate approach. However, responsibility is often given to a single EPC (Engineering Procurement Construction) contractor with their own internal processes for measurement, control, and delivery of a project. The boom bust cyclical nature of the industry has eroded the necessary organizational capability and increased the associated risks leading to the industry morphing into complex project execution models, with greater reliance on owner teams to manage the overall process. The rapid change in virtual technologies has resulted in delineating the design, difficulties in interpreting the completeness of a project stage, and the readiness for execution being more anecdotal than data driven. The high oil price environment that prevailed for almost a decade resulted in the traditional stage gate process being scheduled compressed, with stage gate decisions being made on immature information. The relationship of the measurement schemes between phases and stage gates are often set against different expectations (Morrow 2011).

A step change is required to re-establish discipline in the industry. Standardization of data, measurement, and definitions around stage gates are key concepts to this achieving this.

Unlike the infrastructure industry with relatively low entry cost and multiple entities competing for
work, the energy industry has become bespoke, highly customized with high entry costs, limited supply chain, and the like. However, the speed of technology changes, the emergence of technologies, and the loss of industry capability due to the now sustained low oil price, is providing the industry with a “time out”. The utilization of big data is poised to break the status quo.

Existing construction measurement standards in the Oil and Gas Industry are rooted in methods of measurement for Industrial and Engineering Construction developed in the 1970s (RICS Joint Documentation Board 1984). While these have been enhanced with computer aided taking off systems they do not address needs of global standards, or the issue that projects require data integration. This is evident by the transformation of document control systems into information management and collaboration platforms, the rapid move away from accounting systems to cloud based enterprise-wide cost management software, and the drive to integrate the virtual designs into project execution and operation of assets. In this environment the current fragmented cost measurement standards need standards to remain credible. The ICMS standards potential framework for 'data drop' and 'information exchange' are clear examples of the potential for process improvement and increased transparency.

5.3 Industry Problems – The Construction Sector

The construction sector represents a significant proportion of global economic activity so it is important to incorporate this sector into the overall process accurately. Ironically it is often a large share of economic activity in developing countries, where comparison is most important. Construction comparison requires the development of a data collection and analysis method appropriate to the sector. Methods employed for these comparisons to date have yielded questionable results.

Construction is thus one of the few sectors that are comparison-resistant, because of difficulty in collecting data compounded by difficulty in defining comparable and representative information.

The International Property Measurement Standard (IPMS) has addressed spatial cost comparisons. They are an important econometric process conducted by international monetary bodies for the purpose of poverty identification, standard-of-living comparison, and ranking of income, production, and economic activity levels. Because the construction sector represents a significant proportion of global economic activity, it is important to incorporate this sector into the overall process accurately. Prior to the ICMS initiative, methods did not appear to accurately capture differences in construction costs between nations. The success of the IPMS has help overcome the industry inertia to establish a construction measurement standard.

The ICMS will provide a scalable solution. Most comparisons of construction industry performance require that construction costs be converted to a common base. Existing mechanisms for such conversions produce unreliable results. A proposed method for producing industry-specific conversion factors was tested using a single building type. The lack of a consistent and reliable cost conversion mechanism for comparing construction costs internationally has been acknowledged (Best 2012; Walsh and Sawhney 2002, 2004 & 2005; Blake et al., 2004; Staple, 2002) and it has been demonstrated (Best and Langston, 2006a, 2006b) that the use of different conversion factors in comparative studies can produce quite contradictory outcomes.
DMS International, in research for the World Bank, produced work book modified bills of quantity format for simple building types and cited “over sophistication to price detail” as a barrier to data collection (Sinclair et al. 2002). Similarly, a Eurostat collection on behalf of EU member states (Stapel 2002) found detail did not produce accuracy, but that even simple projects face challenges typically seen in large projects - remoteness of site, allocation of cost between unit, overhead, allocation, cost distribution, allocation of risk, local content in specification, procedure, compliance, productivity and inherent variability. At some point the Pareto rule applies (Brown 2001). Sinclair et al. (2002) note that the RS Means cost guide book Mechanical and Electrical Workbook defines a point at which obtaining utmost accuracy is not economical.

The ‘Law of One Price’ does not hold well for construction output (Vermande and van Mulligen 1999) as built facilities are not tradeable (Schreyer and Koechlin 2002), and are produced and consumed locally. Vermande and van Mulligen go on to explain that a large proportion of the cost of a building is made up of labour costs and basic materials such as bricks, sand and concrete. These are mostly produced locally rather than imported and therefore their costs are little affected by exchange rates. The use of different conversion factors in comparative studies can produce quite contradictory outcomes. There is no consensus on what is the best approach, although there is some level of agreement with the view that the standard projects approach, based on bills of quantities (BQ), is less than ideal due to the difficulty of finding truly standard projects, problems with interpretation and pricing of BQ items in different countries and the high cost of running pricing rounds due to the sheer number of items that need to be priced.

6 CONCLUSION

This paper considered how decisions are currently typically made through the project life cycle, the technological change that is upon us and how this is likely to develop to support decision-making. It then developed themes to highlight the need for unified and harmonized international standards, and why standards will provide the discipline to drive further improve industry performance. The paper illustrated how technology improvements and standards together can be transformational.

While the International Property Management Standard (IPMS) allows consistent measurement of space in buildings, which feeds into both value and cost, the International Construction Measurement Standard (ICMS) will create a framework for a standard system to classify and cost construction projects. Thus, value and cost decisions can be made on the same measurement and definition basis - governments, clients, property and construction professionals can talk the same language both across sectors and across national boundaries.

Both IPMS and ICMS are essential global classifications to allow more consistent intentional use of BIM models. In turn, this will lead to better collection of data for both space and cost prediction and, ultimately, machine learning. As BIM, Big Data and Smart Cities begin to merge as concepts, standard classifications will assume an even more important role in order to make sense of the deluge of data.

Hence, the IPMS and ICMS will benefit financial institutions, investors, clients, consultants, contractors and the supply chain, at a project level; Governments, regulatory and standards setting bodies, and national professional institutions, at a national level; and global financial institutions, investors, clients, consultants, NGO’s and global professional institutions and umbrella bodies, at an international level.
7 REFERENCES


Metropolitan Journal
The winback Nº.1

METROPOLITAN CHAMBER OF GOVERNMENTAL INTEGRATION
RIO DE JANEIRO - NOVEMBER 2015

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A new horizon for the Metropolis

The Metropolitan Region of Rio de Janeiro is enjoying a new experience in its recent history. Expressive and encouraging investments in the territory are the driving forces behind the resumption of economic growth that materializes in large projects. These current changes are overcoming the long period of decline and even stagnation in which the State of Rio de Janeiro had fallen, especially since the mid-sixties.

Today the fluminense landscape portrays a large number of interventions, both public and private, which, in addition to modifying the configuration of the urban/metropolitan space, represent a contribution to the recovery of the population’s self-esteem. Host City for the 2016 Olympic Games, Rio was also host to some of the 2014 Fifa World Cup games in Brazil in June 2014. These major sporting events, together with the number of important works and projects, animate and make the metropolitan scene more dynamic.

It should be highlighted that these actions are not isolated or merely transitory: they are the result of the initiatives implemented by the Government of the State of Rio de Janeiro. The Government, aware of the urgency to establish guidelines and strategies in the area of territorial and land-use planning and economic activities in the region, has been promoting consultations, seminars and studies since 2007, all of which resulted in the approval of the Development Strategic Plan for the Metropolitan Region. The Plan, whose aim is to choose a specific model of Metropolis to be implemented in the short- and mid-term in a horizon of approximately 15 years, will necessarily include the development strategies and priorities established for structural and integrated actions, fashioned as part of the duties of the metropolis and with a supra-municipal nature.

With the firm intention of providing continuity and expressing our purposes with accuracy, in August 2014 we installed the Metropolitan Chamber of Governmental Integration. This agency is included within the organizational structure of the Government of the State of Rio de Janeiro and is resuming articulated actions in the area of urban planning and metropolitan management. We are of the opinion that this initiative broadens the range of discussions, privileging certain aspects related to the public functions of common interest in the metropolis, as well as governance and shared management, urban and metropolitan mobility, preservation of the environment, both natural and built, and also as regards resilient actions in terms of foreseeable and recurrent risks and adverse effects caused by climate changes that impact urban-metropolitan life. It also privileges universal and egalitarian access to sanitation and supply of drinking water, as well as other services leading to social and spatial inclusion in all its multiple dimensions.

At this time it is also appropriate to mention, as regards the juridical and legal framework, the presidential approval in January 2015 of the Statute of the Metropolis. The Draft was discussed at length during the sessions of the National Congress, and the Statute expresses, among other aspects, the relevance of planning and metropolitan management. The new legislation will certainly provide legal support to the interventions to take place in this territorial sphere.
Furthermore, the collegiate decision of the Supreme Federal Court in the case of Unconstitutionality Action No. 1842 (ADI) initially referred to Rio de Janeiro. However, the Supreme Court considered that it might well become a parameter for other regions, as it establishes the shared intergovernmental competence of States and Municipalities to discuss the exercise of public functions that are of common interest to the metropolitan regions.

Both legal instruments of national scope represent a contribution and provide a favorable environment that the Government of the State of Rio de Janeiro intends to promote.

In this regard, and according to the collegiate decision of the Supreme Court, the Metropolitan Chamber of Governmental Integration drafted, in a joint effort with the General Prosecution Office and the Chief of the Cabinet of Ministers, a Draft Complementary Law, on the initiative of the Executive, that sets rules regarding the Metropolitan Region of Rio de Janeiro, its structure, organization and management, while also defining public functions and services of common interest. Among other provisions, it also creates the Executive Agency of the Metropolitan Region of Rio de Janeiro.

However, and notwithstanding all these efforts, we still consider that the great challenge is precisely the modus operandi, the practical and political issues of Metropolitan Governments. Sharing power is not an easy task; the same applies to the efforts made to convince sectors of the relevance and need to launch articulated and integrated programs that must prevail over protagonisms and over the interests of this or that segment. Nevertheless, this must be done and institutional arrangements must prevail, with political courage and determination. Juridical and institutional tools exist and they can facilitate agreed solutions on the occupation and management of the metropolitan territory.

The Government of the State of Rio de Janeiro is convinced that the work already done, and the new paths to follow, will leave an effective legacy of regional development to future generations. The Government is therefore launching this first issue of the Metropolitan Journal, a vehicle for debate between Government and Society, bearing in mind the need to inform about and improve both actions and initiatives.

Rio de Janeiro, November 2015.

Luís Fernando de Souza Pezão
Governor of the State of Rio de Janeiro
ABSTRACT

1.1 Background historical information

From headquarters of the General Government of Brazil, at that time a Portuguese colony, to the Federal District of the Republic, Rio de Janeiro developed and was transformed, in a relatively short space of time, into the largest city in the country and the main port in the South Atlantic.

Around the city and resulting from the distribution made by the Portuguese crown of large settlement areas, several agricultural and industrial establishments were set up and their production was handled through the Port of Rio de Janeiro, and exported to Europe.

This process gave rise to the occupation of areas beyond the administrative boundaries of the city and later on became the current territory of the Baixada Fluminense (the Fluminense lowlands), embracing at present some of the 21 districts of the Metropolitan Region.

As a result of political and administrative decisions, and after alternating periods of vitality and economic decline, the lands of the Baixada were gradually abandoned, creating a gap between the city of Rio de Janeiro and the surroundings, and its effects can be seen still now.

However, in the midst of 20th century, more precisely in 1960, two outstanding facts occurred that complemented each other. The official demographic data\(^1\) reported that for the first time ever Rio de Janeiro was no longer the largest city in the country and, because of the transference of the capital to Brasilia, had lost the privileged status as political-administrative headquarters of the Republic.

That is, in a specific moment, Rio de Janeiro lost its supremacy and the seat of the administration, and this got worse in the decades to come, with significant economic losses. Just in a few years only, Sao Paulo had replaced Rio de Janeiro as the main Brazilian metropolis.

In addition, by virtue of the transference of the Federal District to the central highlands (Planalto Central), a new administrative unit was set up – the State of Guanabara. This initiative problematized even more the relationships between the city of Rio de Janeiro and the adjacent neighborhoods, which was an important urban conglomerated in sparse low-density settlements lacking sanitation infrastructure and were extremely dependent on the city of Rio de Janeiro in terms of the access to sources of employment.

The merger of the States of Rio de Janeiro and of Guanabara only took place in 1974 and finally the city and surroundings formed a unique federative entity, which nevertheless never translated into practical measures, by virtue of the substantive social and economic differences.

More recently, however, the discover of oil in the Pre Sal layer, the industry experienced growth as well as the support activities to the oil exploration in the high seas invigorated the weakling fluminense economy, and this was felt in expressive modifications in the urban structure of the state.

Recovery was also due to the existence of comparative advantages in the quaternary sector, such as higher education, development of research activities, especially in the oil area, engineering services and data

\(^1\) IBGE. Demographic Census, Rio de Janeiro, 1960
processing, tourism and business, entertainment and practices in open spaces. Trade and services account at present for over 78% of the region’s GNDP, while domestic and personal services prevail in the tertiary sector, and close to the underground informal market. Fine chemistry and oil, as well as pharmaceutical products, transport equipment, rubber and plastic industries have achieved sophisticated levels of production, as well as the tourism infrastructure.

Still in the path of recovery, an outstanding real state valuation process can be felt in several areas in the city of Rio de Janeiro, especially in the upscale area of the South Zone - Gavea, Ipanema, Lagoa and Leblon – with the most expensive square meter in the country, together with hotel chains, whose prices are in fact unprecedented.

2. THE METROPOLIS TODAY

The Metropolitan Region of Rio de Janeiro (RMRJ) in the national context

In 1973, on the initiative of the Brazilian government, a federal law instituted the first eight metropolitan regions in the country (Belém, Fortaleza, Recife, Salvador, Belo Horizonte, São Paulo, Curitiba and Porto Alegre); in the following year (1974) the States of Rio de Janeiro and Guanabara were joined together, with the subsequent implanting of the Metropolitan Region of Rio de Janeiro.

This decision was in keeping with criteria coherent with the political circumstances then in effect: a centralizing and authoritarian vision that disregarded the functional relations between municipalities and the qualitative aspects of the metropolis.

In the way that it was presented at that time, the change belied what was announced; in practice, it had no effect on the performance of Public Functions of Common Metropolitan Interest; in fact, it widened the distance between institutionality and spatiality, thereby contributing to making conflicts of responsibilities even more serious.

The notorious lack of articulation between the basic services of urban infrastructure, transportation and sustained use of water resources - which define the exclusive responsibilities of the state and are not matters connected to metropolitan decisions - has led to a process of urbanization of our city characterized by fragmented areas that in turn lead to bottle-necked functioning and environmental inadequacy. With regard to the use and occupation of territory, the steps taken have proved to be insufficient, uncertain and permissive – besides suspected of being unconstitutional.

The absence of a broader perspective of the process of expanding and integrating the metropolitan territory enabled a type of intervention to prevail that prioritized quantity to the detriment of quality. While on one hand this quantitative bias caused the loss of the capacity to discern the cultural meaning of city-planning, opting for extensive and intensive occupation produced a form of urbanism lacking in urban environmental spaces for collective use.

On the other hand, disregarding the urban-environmental characteristics - or even restrictions – seen in various parts of the territory, has legitimized a speculative process that is principally based on continued, irresponsible and uncontrolled expansion of urban-metropolitan boundaries.
Any analysis (even of a superficial nature) of Brazil’s experience in dealing with city administration and planning shows that the procedures that are given priority, by trying to make inequalities homogeneous and by decentralizing through centralization, have granted legal support to a whole series of frustrating failures.

A constant critic of the Brazilian legislation concerning urban matters, Jorge Wilheim, architect, city-planner and former President of the São Paulo Company for Metropolitan Planning (EMPLASA), claims that “the similitude syndrome” that permeates our legislation has allowed cities of different sizes and functions to share the same powers.

Nevertheless, following the States of São Paulo and Minas Gerais, which in 1974 set up city-planning agencies - EMPLASA and PLAMBEL respectively – in 1975 the State of Rio de Janeiro approved a state law creating the Foundation for the Development of the Metropolitan Region of – FUNDREM.

During its fifteen years of existence, FUNDREM, in addition to promoting technical-assistance agreements to draw up guidelines for all the municipalities in the Rio de Janeiro Metropolitan Region, was active in coordinating programs and projects of local interest as well as carrying out relevant studies and research on how to solve the problems of the region.

However, recurrent conflicts as to the specific responsibilities of the institution and municipal administrations eventually weakened the Foundation; following the re-democratization of the country and the granting of more autonomy to local governments, the Foundation gradually lost its political strength.

With the promulgation of the Brazilian Constitution in 1988, the federative States were given the power to institute metropolitan regions, urban agglomerations and micro-regions, “constituted by grouping neighboring municipalities together to integrate the organization, planning and execution of public functions of common interest”. From then on, Brazil has in the last 25 years witnessed the creation of new metropolitan regions in different parts of the federation, thus greatly increasing the nine regions originally created to reach today’s total amount of 61. Twenty of these entities have over a million inhabitants, with populations estimated at between one and five million people. The two main regions - São Paulo and Rio de Janeiro - are home, respectively, to twenty and more than twelve million people.

These 61 metropolitan regions in turn total another 90 million inhabitants, that is to say, about 50% of the Brazilian population, spread over the 22 States of the federation. In the specific case of Rio de Janeiro, the effects of the new Constitutional Charter produced various changes that led to some municipalities being eliminated and others being incorporated, as a result of the dismembering process on the regional level. One year later, in October 1989, when the Constitution of the State of Rio de Janeiro came into effect, a complementary state law formalized the creation of the Metropolitan Region of Rio de Janeiro and instituted the Accounting Fund for Metropolitan Development (FDRM).

Despite its record of relevant services lent to the State of Rio de Janeiro, the agency that until then was responsible for territorial planning in the region – FUNDREM – was made defunct in 1990, on the initiative of the State Executive. As of the extinction of FUNDREM, a gap has been made in integrating and articulating the planning of interventions in Rio de Janeiro. Since then, no other agency specifically responsible for planning the metropolitan territory has been set up.
The dynamic potential for development of the territory involved

Founded in 1974, the Metropolitan Region of Rio de Janeiro has since then undergone various changes in its occupied borders. Originally formed by the municipalities of Rio de Janeiro, Duque de Caxias, Itaboraí, Itaguaí, Magé, Mangaratiba, Maricá, Nilópolis, Niterói, Nova Iguaçu, Paracambi, Petrópolis, São Gonçalo and São João de Meriti, as a result of a series of divisions and emancipations at different times and for different reasons, the RMRJ has taken on new contours. Following successive state laws which complemented the functions granted to the federative States by the Constitution enacted in 1988, these boundaries were altered to include the following municipalities: Rio de Janeiro, Belfort Roxo, Cachoeira de Macacu, Duque de Caxias, Guapimirim, Itaboraí, Itaguaí, Japeri, Magé, Maricá, Mesquita, Nilópolis, Niterói, Nova Iguaçu, Paracambi, Queimados, Rio Bonito, Seropédica, São Gonçalo, São João de Meriti and Tanguá.

With a Gross Domestic Product of the order of R$ 212 million (US$ 93.8 million) and an estimated population of 11.9 million inhabitants, the 21 municipalities that comprise the RMRJ occupy an area of 6.7 million km² and contribute 59% to the taxes collected for the State of Rio de Janeiro.

In spite of such aspects as the attractiveness and mobility - ensured by its prominence as the hub of its neighboring municipalities - the city of Rio configures as a mono-centric spatial model against a periphery with all the characteristics of expansion through contiguity and continuity, today's metropolitan dynamic presents a significantly different scenario of force and spatiality.

If on one hand the city of Rio de Janeiro (the chief municipality of the RMRJ) has been undergoing a sharp decrease in its rate of growth since the 90's, on the other hand evidence points to an impressive demographic growth in the municipalities that border on the city. Even with its own internal dynamic - retraction on one hand and expansion on the other – the municipality of Rio de Janeiro possesses a very different urban space than its metropolitan surroundings.

Chart I – Population, Urbanization and Population Growth of the Districts in the RMRJ

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015 (estimates)</th>
<th>2010/2015 (% variation)</th>
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</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
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The process of demographic shrinkage of the original constituent coexists, side by side, with the intention-
al production of new centralities, and this also assumes a new spatial configuration, tending to the discon-
tinuous multicentrum, reinforced by the closer relationships with the periphery and characterized by the
recent inclusion of production mono-functional poles, such as the Rio de Janeiro Petrochemical Complex
(Complexo Petroquímico do Rio de Janeiro - Comperj) and the Itaguai Port, both connected by the Metro-
politan Arch.

<table>
<thead>
<tr>
<th>GDP at market prices – 2010</th>
<th>GDP at market prices – 2012</th>
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<tbody>
<tr>
<td>District of Rio de Janeiro</td>
<td>District of Rio de Janeiro</td>
</tr>
<tr>
<td>RMRJ without the district of Rio de Janeiro</td>
<td>RMRJ without the district of Rio de Janeiro</td>
</tr>
<tr>
<td>The other districts in the State of Rio de Janeiro</td>
<td>The other districts in the State of Rio de Janeiro</td>
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Source: IBGE and CEPERJ

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tinuous multicentrum, reinforced by the closer relationships with the periphery and characterized by the
recent inclusion of production mono-functional poles, such as the Rio de Janeiro Petrochemical Complex
(Complexo Petroquímico do Rio de Janeiro - Comperj) and the Itaguai Port, both connected by the Metro-
politan Arch.
The first transversal highway vector of the metropolis – the Metropolitan Arch, has transcended its original purpose of freeing cargo and passenger traffic up in the region, is an innovative factor of the RMRJ dynamics, and is characterized as an element able to induced future spatial alternatives and new centralities.

In economic terms, in addition to the role that the Metropolitan Arch is going to play, the RMRJH is also the home of the second largest industrial pole in the country, with predominance of the sectors involved in oil exploration, petrochemicals, metallurgy, gas & chemical, and the steel area. It also gather expressive domestic and international groups connected to the naval sector and to the largest shipbuilding areas, accounting for 90% of the production of vessels and offshore equipment.

The 2015 FIFA World Cup and the 2016 Olympic Games will provide, in the short term, important investments in infrastructure of relevant public transport systems, especially in the case of the commuter traffic of the labor force in the interior of the RMRJ.

In addition to these benefits, these events help to enhance the visibility of Rio de Janeiro, with developments that will certainly benefit the dynamism of the tourism industry and its multiple consequences, especially on the tertiary and housing/real estate sectors.
3. PRINCIPAL OBSTACLES TO THE DEVELOPMENT OF THE CITY

3.1 Some comments

It should never be forgotten that the Metropolitan Region of Rio de Janeiro today exhibits a unique scenario in its recent history, with stimulating investments centered in the region as testimony to the resumption of economic growth materializing in works of significant dimensions.

If on one hand this new phase of prosperity constitutes a powerful attraction of new capital, on the other hand this calls for reflecting on how to make use of the gains that result from these undertakings for the benefit of guaranteeing a better Rio de Janeiro, a place where the quality of life of its ensured by cities that are more united, more hospitable and better equipped.

One of the main obstacles to be faced, indeed the Gordian knot of the whole matter, has to do with the historically fragmented conception and implementation of public policies, as evidenced in the isolated and sectorized response to demands for better living conditions.

This is made clear when the issue repeats themes such as housing, the lack of integrated basic-sanitation systems, access to water via a public-distribution network, or - with regard to draining – the collection and final destination of solid waste.

On the same theme, add the various demands for action with regard to urban mobility articulated with one another and with other public policies, concerning the quality and accessibility of transportation as well as the time spent in transit, the connections to be made and the fares to be paid.

To the extent that universal and equal access to the benefits produced by society is translated, firstly, into distributing collective-consumer goods, this proposal can only be satisfied by means of a democratic management of the region that respects and prioritizes the social function of the cities contained in its territory, privileging human and urban dignity in all its aspects.

A healthy urban environment presupposes providing dignified housing served by quality public transportation, guaranteed infrastructure and other urban facilities compatible with demand, in addition to ensuring access to jobs.

Emphasis should be made of the urgent need to qualify different points in the metropolitan territory, respecting their physical and environmental conditions, in particular those where providers of services and generators of new urban dynamics are located. These initiatives should promote urban-environmental improvement of the new areas, encouraging diversity in the use of the land, shortening itineraries and costs of connections, controlling prices of city property, disciplining urban density by means of optimizing the production of the set of networks for transportation infrastructure, communications and supplying sanitation and energy services.
3.2 Actions, objectives and challenges

One of the aspects to be pursued, as regards overcoming hurdles that inhibit the development of the metropolis, refers to valorizing places of prominence in the many cities that make up the RMRJ by potentializing the functional relations established between them and the characteristic typologies, their respective identities and the constructed and natural heritage seen in the public spaces associated with - and defined by - articulation and harmonious living.

A second aspect has to do with connectivity, and sets as a sine qua non making concrete actions in favor of agile efficient and inexpensive transportation, as well as shortening peak times, decentralizing areas that generate traffic, making intermodal means of transportation compatible for the purpose of integrating and adjusting policies on fares.

A third theme to incorporate with the other two refers to overcoming current disadvantages by using formulated strategies of sectorial diversification and scaling the various poles of production and services that dynamize the economy of the region.

The hypothesis underlying this idea presupposes that such diversity tends to potentialize the economy and induce the action of the government to seek better collective services as to infrastructure and installations that qualify the territory. On the other hand, direct actions made in conjunction with decision-making sectors and articulated with the dwellers of the communities and with other instances that become necessary, are assembled together in policies and management arrangements geared to strengthening governability, involving the various producer-agents of the cities who incorporate business opportunities and economic promotion on behalf of planned and participative urban development.

Carrying out the social functions of the cities that make up the RMRJ calls, therefore, for a mobilization of the local forces, public and private institutions with the active participation of the communities involved, in support of a re-ordering of the territory to stimulate economic development. Likewise, the economy will also be made dynamic through public participation in drawing up and implementing new forms of collaboration and partnership, bearing in mind the coordinating of the many interests and demands of society.

Given these observations, and with a view to reclaiming the historically accumulated social liabilities, a new perspective of city planning for the Metropolitan Region of Rio de Janeiro must prioritize the following structural areas:
3.2.1 Accessibility and Mobility

The problems that involve the crisis of urban mobility spread over several approaches that range from the reflexes of economic and fiscal policies that determine the investments profile for the sector, to factors of a political-institutional nature.

In the RMRJ, the absence of an integrated treatment of the urban system of transportation and mobility, allied to lack of understanding of the influence that the processes of productive re-structuring exert on the forms and flows of mobility, has led to projects that proved inadequate. Implanting corridors of city transportation capable of reaching satisfactory levels implies verifying the possible metropolization of stretches of federal railroads as an alternative to alleviate important arteries which, once incorporated into the urban network, underscore the need to resort to predominantly metropolitan methods.

3.2.2 Urban Centralities and Connectabiliites

Implanting the Metropolitan Arch points to some predictable aspects that result from the insertion in the city’s landscape by joining federal railroads that come and go to Rio de Janeiro. Re-organizing the flows in and out of these railroads will divert the heavy traffic of long-distance commercial vehicles (buses and trucks), which in turn will remove cargo transportation from the main areas typically used as city corridors, with subsequent benefits in terms of traffic flow and safety for vehicles and pedestrians. This measure, taking into account the necessary barriers and transitions between the vectors of expansion and the Units of Environmental Conservation in the region, will enable accelerating the travel time between regional centers and sub-centers and redistributing the importance of the present centers. These and other structural changes will allow modifying the polarity of the existing centers by producing a poly-nuclear and better-balanced metropolis.

3.2.3 Metropolitan Installations

Considering the force of polarization and the capacity of re-structuring urban installations in the city space, whether they are dedicated to infrastructure or to installations of a socio-cultural nature, any actions that come to be taken must consider those that harmonize the vectors of expansion with restrictions to occupation set down by the Units of Environmental Conservation that exist in the region.

Localizing these installations must first of all take into account the interventions meant to de-concentrate the metropolis, to the extent that some of them, given their size or scope, constitute elements liable to become instruments of territorial structuring that generate new centralities, or else new road congestions in already enshrined centers. Hospitals, universities, transportation terminals and public security can induce new centralities or attract traveling to areas known to be congested.

Special attention should be paid to the location of regional health installations (hospitals and public UPA clinics), as well as those dedicated to education (universities, secondary schools, technical schools) and to logistical safety agencies, since equal and dignified service provided to the population residing in the other municipalities of the RMRJ alleviates the already over-burdened network of such services in the city of Rio de Janeiro.
3.2.4 Environmental Sanitation and Integrated Urbanization, Managing Water and Generating Energy

Selecting areas of intervention connected to Environmental Sanitation and Integrated Urbanization, together with the respective treatments of waterways, calls for actions in regions due to suffer greater demographic pressure, based on industrial and logistics investments in the metropolitan territory.

Accordingly, given the insufficiency of hydro and energy resources caused by the ever more frequent occurrence of floods due to climate changes, during the planning process it is necessary to establish mechanicals to control flooding and reserving areas to accumulate water designed to supply and generate energy.

3.2.5 Economic Re-structuring

The economy of the RMRJ has been recuperating from a lengthy period of decline and stagnation suffered in the last four decades. More recently, the RMRJ received a significant mix of investments, mostly in the port and steel sectors in the region of Itaguaí and the Petro-chemical Complex (COMPERJ) located in Itaboraí; added to other initiatives, these amount to total investments of over R$ 120 billion (US$ 48 billion).

In the light of this scenario, it is necessary to adopt strategies that consider and drive the potential leveraging of the municipalities of the RMRJ, with a view to reducing the considerable asymmetry that exists in the region.

Furthermore, the investments capable of complementing the productive chains should be verified, as well as identifying and quantifying the locational demands by type of activity, generators of work and income opportunities, especially with regard to small and medium companies.

For this same purpose it is also advisable to stress the importance of a thorough evaluation of the logistical capacity of the Airport Complex of the State of Rio de Janeiro, taking into account its effective present and future operational viability, as well as its direct and indirect impacts on the metropolitan territory.

3.2.6 The Natural Environment

The Metropolitan Region of Rio de Janeiro embraces an exuberant natural heritage that includes extensive areas of vegetation, beaches, bays, numerous waterways, sandbars and mangroves. Inserted inside one of the sectors of the Atlantic Forest bioma of incomparable biodiversity, the RMRJ boasts a varied gamut of natural landscapes that stretch from sea level to the highest points of the Organs sierra to the north.

Nonetheless, one sees that the conservation and preservation of this rich diversity is being severely affected by anthropic activities, as expressed in the growing number of species of flora and fauna that are vulnerable or threatened with extinction, as well as in the intensive pollution of hydrographic basins.

On the other hand, the impacts of climate changes contribute to increase the chances of recurrent tragedies that cause loss of life, both human and environmental, as well as damage to and loss of property, such as the tragedies that punished the region in 2010, 2011 and 2013.
The heavy rainfall brought about avalanches, landslides, floods, fallen trees, problems in energy transmission and sea-swells; the rain washed away soil, rocks and trees and left a scenario of destruction in the places affected.

In light of this and aware that the economic and social development and the environmental protection are interdependent and inseparable of sustainable development, a rational and balanced use of the natural resources of the RMRJ is essential. This must be based to a prior planning of interventions, in the responsible management of the areas of permanent protection (APPs) and in the recovery of the areas abandoned, degraded our occupied by informal settlements.

The adaptation or resilience, for the purpose of anthropic activities, in addition to those originated from climate changes that demand integrated and coordinated actions that involve several scales and topics, need to include actions in the metropolitan area, hydrographic basins and municipal territories until they reach specific scales (hillsides, lagoons, basins, mangroves, and so on) which are identified according to their degrees of vulnerability.

However, it should be recalled that these actions cannot offer homogeneous responses, much less being addressed as isolated or episodic cases. The various situations seen today in the RMRJ demand contingency plans able of monitoring and assessing risks of floods and landslides, which extrapolate the limits of this or other districts.

The ARMRJ includes elements (projections, plant coverage, infrastructure, productive activities, and so on), flows (of people, vehicles, cargo, services, and so on) and vulnerabilities (tendency to landslides, availability/quality of water and other risks associated to industrial complexes, etc.), which make combinations in a differentiated manner, according to the area of the metropolitan space under analysis.

Both government and society are aware that the aforementioned policies should join those related to monitoring of emission of contaminating gases that compete to disqualify the natural environment and the work at the RMRJ.

With that in mind, it is essential to take into consideration low carbon measures, especially those related to motor vehicles used in transportation, largely used in the RMRJ, through the integration of railway and subway transportation.

The urban-metropolitan environmental management is still lacking more inter-municipal cooperation and coordination, and among the regulating agents and entrepreneurs, as these sectors will fatally be directly involved in the adaptation measures vis-à-vis climate changes, in any metropolis whatsoever.

After so many and serious accidents, especially those that occur in the case of great rains, the general expectation is that life in the metropolis must avoid emergency solutions. Prevention is, undoubtedly, the feasible response and is much cheaper than remediation, even because there is no remedy in the case of loss of lives.
In this regard, in order to make preventive and to encourage viable actions for the urban-environmental preservation at a metropolitan scale, the priorities are:

- the preservation and conservation of the biodiversity corridor at Serra do Mar;
- the preservation and conservation of ecosystems;
- the recovery and conservation of the Guanabara and Sepetiba bays;
- the definition on areas restricted to urbanization, by virtue of the tendency involving geological risks, in addition to floods and pollution;
- the adequate and efficient management of solid waste;
- universal access to basic sanitation and drinking water, through the public distribution network;
- the proper supply of drainage systems;
- the regulation on the soil use and occupation;
- the definition on guidelines expressing the metropolitan interest regarding public duties of common interest;
- the recovery and conservation of air quality and noise control;
- the planning and proposal of tools for the forecasting and reduction of risks in the case of climate accidents;
- the assessment of vulnerabilities, together with adapting solutions or resilience, such as strategies for the preservation of human life, of the natural and built environments and of material and patrimonial assets.

3.2.7 Management and Planning in the Metropolitan Region

The current process of expansion and globalization leads to a higher concentration of activities, which are centralized and operated in large cities. In turn, they demand a higher degree of planning, management and monitoring abilities from the public authorities, vis-à-vis the occupation arrangements in their territories, causing many times conflicts of competence among the local administrations (the city) and the State administration.

In the RMRJ particularly, the ostensive presence and influence of federal agencies and equipment over the courses and direction of the Metropolis, the remainders of the old Federal District of Rio de Janeiro, help to aggravate those conflicts.

As per the current discussions not only about the strengthening of the management tools but also on the structure of the decision instances themselves, a new governance profile is prone to establish the strict
duties and attributions of the public administration on the regulation, the defense of equity and of social promotion. This will also facilitate the involvement of the civil society in the activities in which the private sectors appear more dynamic.

3.3 For a Vision of the Future

After the extinction of the FUNDREM (1990), the absence of integrated planning, as articulator of the interventions in Rio de Janeiro continued during successive administration until 2010, the year in which, by initiative of the State Government, negotiations started with the World Bank, with the aim of creating favorable conditions for the study and drafting of development policies for the metropolitan territory.

With the firm decision of overcoming obstacles and hindrances that prevent the full development of the region, and also to concretize core metropolitan structures, the State executive power is making endeavors for promoting the re-organization of the metropolitan territory, including the preparation of studies for drafting a proposal to organize the win back of management, on the basis of effective Metropolitan Governance.

For that purpose, the Under Secretariat of Regional and Metropolitan Urbanism Projects of the State of Rio de Janeiro drafter the Terms of References for implementing the Strategic Development Plan of the Metropolitan Region of Rio de Janeiro, which identifies the priority lines of intervention and establishes a set of affirmative actions that guarantee the egalitarian development of the region and, by consequence, of the State and districts.

At the same time, the Plan will also be the instrument capable of restoring in the State, the practice involving physical and territorial planning, following a prior study on the installation of new socioeconomic opportunities, taking into consideration the promotion of the internal regulations for the metropolitan territory.

This initiative implies the confirmation that the political commitment accepted assumes the assurance of processes agreed with society and environmentally sustainable, both at the local and regional spheres, taking into consideration the peculiarities and the originality of the RMRJ, that make its unique among the other regions of the country.

Among the mechanisms chosen to achieve these objectives, a 2011 Decree established the Executive Committee of Metropolitan Strategies, which is made up of several State Secretariats and with the involvement of the Rio de Janeiro State University (Universidade Estadual do Rio de Janeiro - UERJ), and introducing also some counseling tools.

Under the coordination of the State Vice-Government and with the support of the World Bank, the Committee convened several monthly meetings, technical visits in Brazil and abroad, courses and exchange of experiences with other States of the Federation, having as a focal point the setting up of the strategic planning of the region. It also carried out further studies and drafted assessment documents on the diversified faces and connotations of the metropolitan problems, with a definition of appropriate strategies in order to establish a vision of the future for the metropolis of Rio de Janeiro.
Among the diverse aspects addressed, the Committee highlighted not only the relevance of the cultural and environmental heritage of the RMRJ, but also the urgent need of measures that help to preserve the heritage.

Since then, a preliminary proposal was launched. Its aim was to establish a Metropolitan Governance, articulated and integrated among State secretariats and districts.

Another initiative complemented the Strategic Development Plan of the Metropolitan Region of Rio de Janeiro in the area of transports – the requalification of the stations of the Fluminense railway system and of adjacent areas, providing them with accessibility compatible with the potential demand. This will in turn fuel the value of the referential places, in terms of densification through the vertical occupation of the soil within a radius of 850 meters in the surroundings of the main stations.

The Urban Restructuration Plan of the Surrounding Stations intends to implement the concept of urban mobility with a focus on the integration of the railway system of the RMRJ to the other urban systems. This initiative results from the evidence that interventions based on recovery as available lack supplementary investment that would allow them to achieve the effects leading to the recovery and the increase of the demand for railway services by the population of the carioca suburbs and of the Fluminense lowlands.

Therefore, the Government of the State of Rio de Janeiro considers that in order to recover the adjacent urban area is essential for the improvement of the railway system. In summary, the proposal is to condition the urban interventions to the spaces adjacent to the railway station, so that the improvement in terms of mobility and accessibility help modeling the urban project, where railway services are in fact privileged.

The two plans inter-communicate and converge for the same purpose, i.e. the full physical and spatial development of the Metropolitan Region of Rio de Janeiro, which in turn will serve as a guide for the additional policies and interventions in the territory.

In the meantime, in order to achieve this main purpose, a metropolitan authority for the RMRJ is needed. The authority must consider, in addition to the leadership of the Government of the State of Rio de Janeiro in the leadership of the process of implementation of the plans and projects, the totality of the endeavors made to build and maintain of the political covenants and consensus, involving the municipal administrations, the sectors representing the society and the private initiative.

As there is no ideal model in terms of metropolitan governance, the challenge before us is to produce appropriate management formats based on legitimate and consensual partnerships able to perfect and quality the region’s potential.

With the aim of continuing and better articulating the ongoing actions the Government of Rio de Janeiro established in August 2014 the Metropolitan Chamber of Governmental Integration, a collegiate organization shared between the State and the districts of the RMRJ.
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- Senge-RJ
- fisenge
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- BOCATER
- CAIXA
- MINISTÉRIO DA SAÚDE
- Brasil

**Support**

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- ABC
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