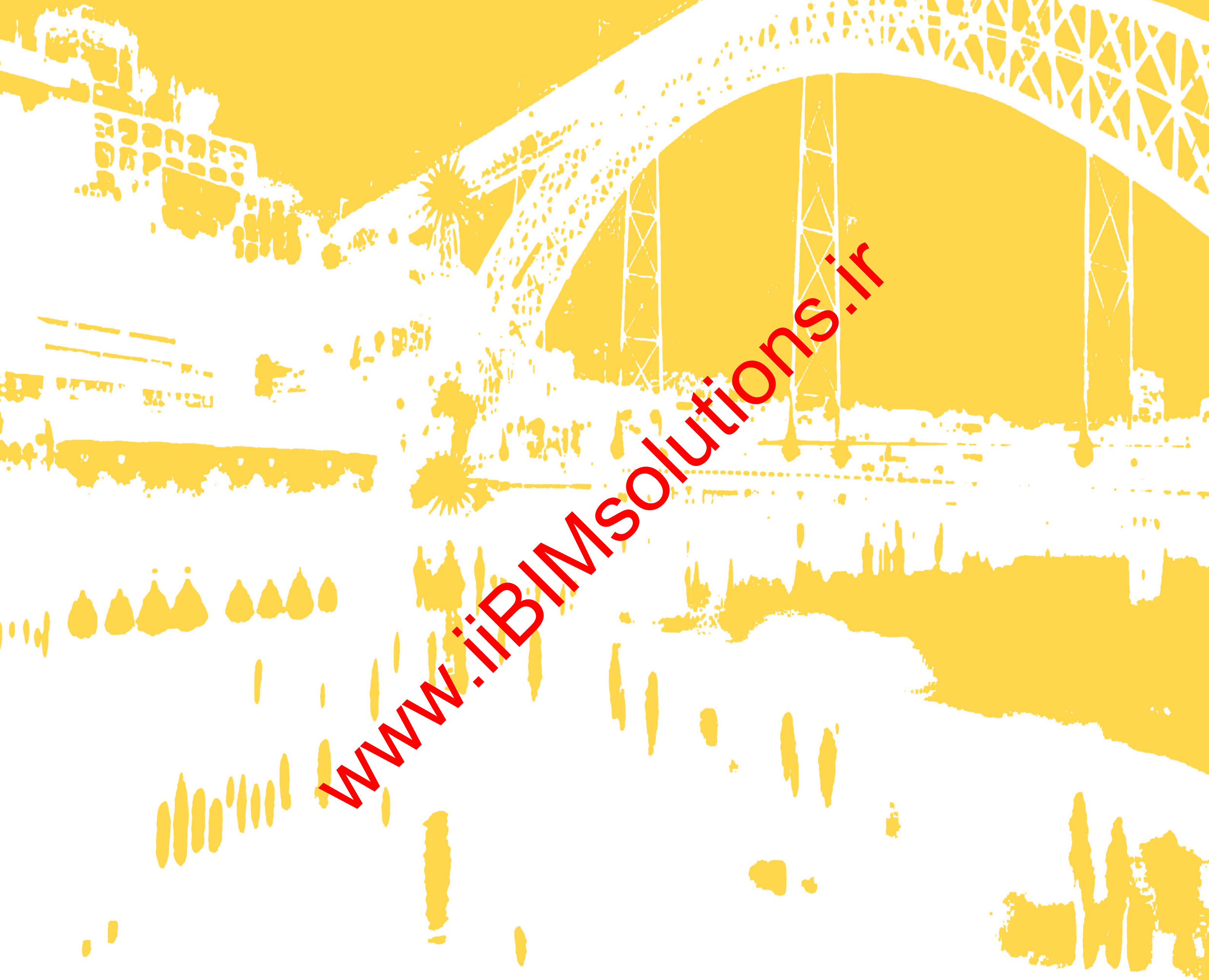
BIC 2013



Building Information Modeling

A new construction paradigm

1st BIM International Conference

BIM Portugal FORUM

Editors: António Aguiar Costa, Paula Couto and António Ruivo Meireles

BIMForum Portugal
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Paul Morrell, formerly Chief Construction Adviser to the UK Government

As somebody now past retirement age, I can honestly say that the construction industry has provided me with both job satisfaction and a fulfilling career. I've met some great people, and we have worked together to make the places where people live, work and play. That is a worthy calling, even noble at its best.

However, I have spent too much of my life arguing: with contractors who have misunderstood and underpriced work, or who simply have an over-ambitious view of what something is worth; with designers whose information is late, incomplete or uncoordinated, and/or is produced with a blissful disregard for the budget; and sometimes even with clients, whose aspirations and budgets are misaligned but who imagine that they are immune to normal market forces.

Of course, all this argument gets paid for – either explicitly, or because we are so used to it that it has become embedded in our terms of trade; and almost all of it represents waste, without which all of those ambitions and aspirations would be more capable of realization.

That is a much more positive story, and I think there is one fundamental change in the structure and practice of the industry that could bring that positive scenario within reach – and that is integration.

This calls for the many people whose skills are necessary to conceive, design, construct and manage and maintain built assets to organize and align themselves around the simple objective of understanding clients' needs, and then delivering value to them on the basis of that understanding.

For all of the technical potential of Building Information Modeling, therefore (and that is already so great as to be beyond our imaging), it is its potential to transform the structure and practice of the industry that I find most exciting. It will not, of course, do that on its own: but for those who are looking to reposition their business so it is more closely aligned to the genuine needs of clients, and who want to work with like-minded people, BIM can be the tool through which they first collaborate, and then integrate their processes.

That will, of course, make those businesses more competitive, and therefore more able to survive and prosper in a world where the old order is shifting. The irony, though, is that to get the best of BIM, we need to set aside some of our competitive instincts and agree standards and codes that enable us to work together without barriers of language or systems. Competition must then come in how we use the tools of BIM, not how we design them; and in innovation around applications, not systems and standards.

This, of course, requires us to do the very thing that we have not been so good at: talking collaboratively for the benefit of our clients – and therefore ultimately for the benefit of the industry.

Organisations, conferences and gatherings that join together people in the industry, and then join together industries between nations therefore have an important part to play in fulfilling the potential of BIM to serve the real objective: better buildings that are both more affordable and well suited to our clients' needs.

The 1st BIM International Conference held in Porto in May 2013 was a great example of this reaching out; and the summary of proceedings included in this publication provides an excellent introduction to the subject for new entrants, and plenty of ideas for those already engaged. I commend it to you.

1. Introduction

Despite the inertia within the construction industry in relation to innovation in recent years and the failure to respond to the increasing need to reduce waste and improve performance, several innovative technologies have emerged in the construction sector. New Information and Communication Technologies (ICT) have challenged traditional working methods and stimulated change and modernization. Slowly but surely, these technologies are being incorporated into construction processes, demonstrating that potential gains are possible.

Amongst the most recent ICT developments in construction, the particular importance and growing use of Building Information Modeling (BIM) is particularly noteworthy. BIM is already recognized as a new construction paradigm, one that is indeed changing processes and behaviours. BIM makes it possible to construct an accurate 3D virtual and parametric model of a building, containing the precise geometry and relevant data needed to support the construction, fabrication and procurement activities necessary for the building process [1]. It also fosters project understanding and integrated and coordinated decision-making in supply chains, providing the construction industry with an instrument to support more rigorous and consistent decisions along a building's life cycle [2].

Behind this vision, collaboration emerges as a major challenge. The building information model can be shared along the supply chain and collaborative work is stimulated. However, this leads to another challenge: the data exchange between all parties involved requires seamless interoperability. Efforts to address this problem have focused mainly on the development of standard formats, such as the Industry Foundation Classes (IFC) [3]. Step by step, the construction industry is gradually understanding the importance of interoperability, with a view to establishing integrated and automated work processes that will result in cost and time savings. As more segments of the construction industry adopt BIM and integrated design and delivery processes, this issue is becoming all the more evident [4].

Industry leaders and government agencies now recognize the importance of addressing the issue of interoperability and a growing number of reports continuously document the imperative need to solve this problem.

Despite these BIM-related interoperability issues, businesses are implementing it in their organizations and projects and several international initiatives have already demonstrated effective performance improvements [5,6]. It is interesting to see that, as a consequence, the mandatory use of BIM is being discussed at the international level, and several countries – such as the United Kingdom, USA, Finland, Singapore, to name just a few – already have set deadlines for mandatory BIM use in public works, which will, in turn, bring about significant changes within the construction industry.

The 1st BIM International Conference took place in a context of intense BIM-related interest and activity, giving rise to many questions as to its viability, return on investment, interoperability or complexity of implementation. Accordingly, this international conference seeks to contribute to achieving clarification on these issues, inviting BIM leaders to share their experiences and all BIM enthusiasts to present and discuss their points of view. Naturally, the lifecycle and integrated perspective have been taken into consideration by the conference organization committee, specifically by inviting keynote speakers representing the various stakeholders in the construction supply chain. Similarly, special attention has been given to the interoperability concerns, as reflected in the presence of several software firms and interoperability and IFC specialists. The scientific and technical papers also contributed to a wider discussion and clarification, particularly by their international and diverse perspectives.

This conference book introduces the keynote speakers and provides a summary of their speeches. Furthermore, all the extended papers presented in the scientific and technical sessions are made available, in the hope that this can be conducive to generating greater BIM consciousness.

[1] Eastman, C.; Teicholz, P.; Sacks, R. and Liston,K.; BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, John Wiley & Sons, 2011.

[2] Thorpe, A.; Buswell, R.A.; Soar, R.C. and Gibb, A.C.G.; VR or PR: Virtual or physical reality?, in: Brandon, P.; Kocaturk, T. (Eds.), Virtual Futures for Design, Construction and Procurement, Blackwell Publishing, Oxford, UK, 2008, pp. 35-46.

[3] BuildingSmart, IFC overview, 2013. www.buildingsmart.org.

[4] Lipman, R.; Palmer, M. and Palacios, S.; Assessment of conformance and interoperability testing methods used for construction industry product models, Automation in Construction 20 (4) (2011) 418-428.

[5] Barlish, K. and Sullivan, K.; How to measure the benefits of BIM — A case study approach, Automation in Construction 24 (2012) 149-159.

[6] Bernstein, H.M.; Jones, S.A. and Gudgel, J.E.; The Business Value of BIM in Europe: Getting Building Information Modeling to the Bottom Line in the United Kingdom, France and Germany, SmartMarket Report, McGraw-Hill Construction, Bedford, UK, 2010.

It is general knowledge that the construction sector has a considerable influence on national economies. However, it is a fragile and stagnant industry with low productivity and low innovation indices, showing itself to be slow to adopt new technologies and modern management methods. This, in turn, negatively affects the resilience of national economies.

Of the most important factors that explain this behaviour, some are particularly significant: high market fragmentation, strong price-based competition, lack of project uniformity, lack of a highly trained workforce, project location diversity and lack of trust amongst players [1,2]. Each construction project has specific characteristics depending on numerous uncontrollable variables (such as the weather or site conditions), involves a significant number of players, has a disintegrated lifecycle (several phases may exist and the actors may differ from phase to phase), requires large amounts of usually dispersed information, is disparate in nature (various products may be used for the same purpose) and requires considerable investments. All of these characteristics make each construction project unique and create challenges for the construction industry.

If addressed inadequately, this complex and demanding environment may lead to numerous errors and substantial losses. In Portugal, a global report on five public works projects with direct State management [3] shows the relevance of this concern. Audits found a widespread phenomenon of serious cost overruns (between 25% and 295% above the ceiling rates defined by the contracts), and, cumulatively, significant deadline deviations (between 1.4 and 4.6 years more than scheduled completion deadlines). According to the Portuguese Court of Auditors, the primary causes for cost overruns and deadline deviations in construction were the following:

- lack of rigour and quality of tender documents;
- errors and omissions in design documents;
- numerous changes to designs;
- lack of preliminary studies and project revisions;
- modifications to work and extra work due to project errors and omissions, unforeseen events, and improvised or last-minute solutions;
- work carried out at the same time as design projects;
- delays in expropriating land and obtaining an Environmental Impact Statement;
- construction process modifications;
- uncertain geological conditions;
- deadline extensions;
- lack of interoperability and bad communication between stakeholders;
- bad planning and project management;
- bad supervision;
- force majeure causes.

Against such a complex and dynamic background, innovation emerges as vital to successful, long-term company performance in the construction industry, and a requirement for organizational growth or survival [4]. However, investment in ICT in the construction industry is extremely limited. In the case of Portugal, in 2009 the total investment by businesses in R&D corresponded to 0.78% of GDP, of which only 0.01% came from the construction sector (Eurostat, 2011). This is extremely low, and is all the more reason for concern when one considers that the Portuguese construction industry represents about 6% of GDP.

In order to combat the inertia within the industry and stimulate modernization, particularly in terms of BIM implementation, which is generally regarded as a disruptive ICT, the BIMForum Portugal was founded in 2012. This professional group is made up of a consistent network of BIM enthusiasts, professionals and researchers in architecture, engineering and construction (AEC) who feel that AEC practice, education and research have to be radically revised if the sector is to respond to the challenges ahead. Since its foundation its mission is to promote BIM in Portugal, involving the whole construction chain in the development of best practices and standards for virtual construction management (design, construction and operation), thus assuring the greater distinction of, and a competitive advantage for, the stakeholders amongst their international peers.

The 1st BIM International Conference was one of the initiatives of the BIMForum Portugal, in partnership with the BIM group of the Portuguese Technological Platform for Construction, and aimed to discuss BIM implementation worldwide and also generate synergies for a more competitive industry by incentivizing the development of a BIM cluster capable of exporting its BIM knowledge and competences. We believe that these initiatives will encourage BIM implementation in Portugal but we also comprehend that major challenges must be dealt with, particularly by the national government bodies.

António Aguiar Costa

[1] Alarcon, L.F.; Maturana, S. and Schonherr, I.; Impact of Using an E-Marketplace in the Construction Supply Process: Lessons from a Case Study, Journal of Management in Engineering 25 (4) (2009) 214-220.

[2] Ekstrom, M.; Garcia, A. and Bjornsson, H.; Rewarding honest ratings through personalised recommendations in electronic commerce, International Journal of Electronic Business 3 (3-4) (2005) 392-410.

[3] Court of Auditors, Global Report of five Public Works Developmets, through direct State management, Court of Auditors, Lisbon, 2009.

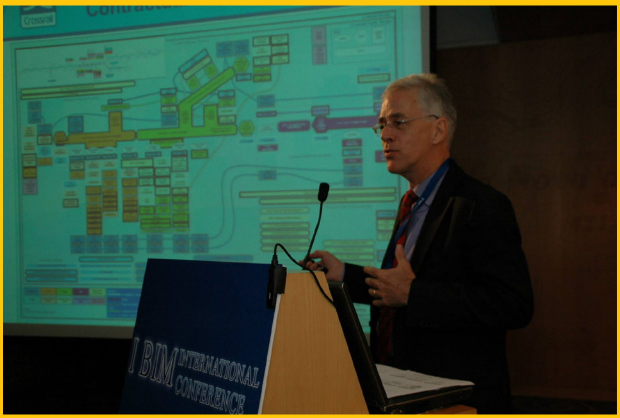
[4] Gambatese, J.A. and Hallowell, M.; Enabling and measuring innovation in the construction industry, Construction Management and Economics 29 (6) (2011) 553-567.

3. Keynote Speakers

Paul Morrell, formerly Chief
Construction Adviser to the UK Government

Kari Ristolainen,
MSc, Architect, SAFA, FISE AA

Heikki Kulusjärvi
buildingSMART Finland Board Member and
COBIM co-author



Malcolm Taylor
"Head of Technical Information" for Crossrail

Paul Morrell has recently completed his term as the Government´s first Chief Construction Adviser, having been appointed in November 2009 with a brief to champion a more coordinated approach to affordable, sustainable construction. He is a chartered quantity surveyor and was formerly senior partner of international construction consultants Davis Langdon, where he had worked since graduating from university until retiring in 2007.

He is a fellow of the Royal Institution of Chartered Surveyors and the Institution of Civil Engineers, and an honorary fellow of the Royal Institute of British Architects; served as a Commissioner on the UK Government´s Commission for Architecture and the Built Environment from 2000 to 2008; and was awarded an OBE in the 2009 New Year Honours list.

In Government, Paul led the BIS Innovation and Growth Team study into low carbon construction and the development of the Government Construction Strategy, which included a strategy for Building Information Modeling.

He now practises as an independent consultant.

Paul Morrell, formerly Chief Construction Adviser to the UK Government

Title: The Role of Government in Promoting BIM – the UK Experience

Main content: BIM is increasingly recognized as having the potential to create a new paradigm for construction. This calls for the industry and its major clients to develop strategies to encourage and keep pace with beneficial change.

Good strategies identify the problem to be solved (diagnosis), posit remedial action in response to that problem (prescription), and then put in place a detailed proposition for the implementation of remedial measures (treatment plan). Strategies developed by the UK Government, working with industry, address all three.

Main topics: The problem: high cost, low productivity (and virtually zero improvement in productivity) and projects that frequently miss their targets (in respect of outcome, intrinsic quality, cost and/or program), as a consequence of:

- the complexity of industry structures and relationships;
- silo mentality and a lack of integration;
- low initial capital cost being prioritized over whole life value;
- confused communications and wasteful processes as a consequence of all of the above;

all at a time when we face unprecedented challenges.

Action in response to the above:

- the importance of integration and the alignment of interests;
- innovation and the potential in the supply chain;
- the specific and broader contribution of BIM.

The role of Government, as both client and sponsor of the industry, in stimulating change:

- process mapping and organizing itself as an effective client;
- the market failure implicit in an excess of choice;
- standards, protocols and training.

A look ahead to the longer term impact of BIM on the structure, conduct and performance of the construction industry.

Learning objectives:

- How BIM addresses structural problems in the industry
- What government should (and shouldn't) do
- The perils of inaction.

Mr. Kari Ristolainen is working with Parviainen Architects Ltd, Finland in a principal architect position from year 2012 to the end of 2014. During this two years leave from Senate Properties he is working as a principal architect for shopping mall refurbishment.
Kari Ristolainen has worked (2002-2012) with the Senate Properties Finland Investments Team, in an chief advisor position, to enhance the design, construction and maintenance processes, as viewed from the Owner's perspective, through the use of Building Information Modeling (BIM).
He holds a Master's Degree in Architecture from Helsinki University of Technology (1983, today Aalto University) and has been working in his field prior to his role with the Senate Properties. His expertise lies in renovation projects. Prior to his position with the Senate Properties, he worked with many architectural firms. (1983-2002).

Kari Ristolainen, MSc, Architect, SAFA, FISE AA

Title: Decade of BIM – Benefits and Challenges

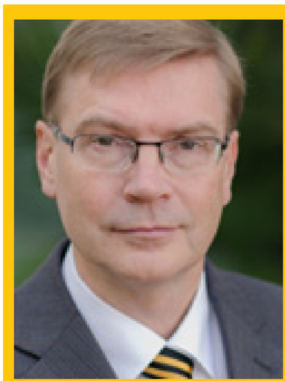
Main content: Use of the existing buildings and properties is the main challenge. It's important to collect up-to-date data of the buildings and their renovations and updates. BIM helps in question of ergonomics in communication concerning advices and requirements. Methods of energy savings and reducing emissions has to be easier to maintain and end-user friendly.
Senate Properties' all property and service solutions are based on environmental and economical and social sustainability. One key factor for getting better buildings is to use efficient and reliable energy analysis in the concept design stage. In Finland we need new contract forms to divide benefits and risks equally between the parties.
Case: Initial data mapping with laser scanning of HVAC installations and bearing structures.

Main topics:

- Challenges and possibilities in the built environment
- Better buildings and less energy usage
- The Common BIM Requirements 2012
- Accurate BIM

Learning objectives:

- BIM and Quality hand in hand
- BIM and refurbishment
- New contract forms needed



Mr. Heikki Kulusjärvi is one of the pioneers in promoting Building Information Modeling (BIM) and developing practical solutions for the area. He has been involved in International Alliance of Interoperability and BuildingSmart work early on. He is currently a board member of buildingSMART Finland. He is also the managing director and the founder of Solibri, Inc.
He has been developing practical BIM guidelines/requirements for Skanska Finland and YIT Corporation, The Confederation of Finnish Construction Industries RT, Senate Properties, General Services Administration (US) and National Common BIM requirements of Finland.
He has more than 28 years expertise on the field of product Modeling; BIM and Product Lifecycle Management (PLM) of which 19 years in Knowledge-based Engineering and Artificial Intelligence tools. He was involved in the very first fully computer aided design projects for buildings in Finland during 1984 – 1985.

Heikki Kulusjärvi
buildingSMART Finland Board Member and COBIM co-author

Title: Meaning of "I" in BIM

Main content: Traditional document based design is based on interpretation of documents, meaning that each stakeholder extracts or measures the information they need from the documents the way they believe is right. This is not always how it was intended in the first place leading to misinterpretation and quality problems, extra costs and schedule delays.
The idea of BIM is that information is carried in the process as it is. Thus managing information is the key in BIM based processes. During first steps to BIM utilization information is used for example for Design Coordination, Quality Assurance, Quantity Take-off, Area Calculations etc. All these use cases have specific requirements for the information and the quality of it. This is why it is of paramount importance to define what information is actually required and how this information should be modeled in the BIM authoring tools. Open BIM standard (IFC) gives wide possibilities to exchange information between stakeholders in projects but that is only the framework.
To make modeling successful, project-specific priorities and objectives must be set for models and model utilization. Project-specific requirements will be defined and documented on the basis of the objectives and general requirements set in local BIM requirements.

Main topics:
- Steps taken by leading BIM countries in BIM Adoption
- Why local BIM Requirements are important
- Introducing selected local BIM Requirements
- Insights of making BIM Requirements
- Recommendations

Learning objectives:
- Information in BIM makes it work, but needs to be defined
- Learn what others have done with BIM Requirements

Malcolm Taylor is "Head of Technical Information" for Crossrail in London, UK. His current responsibilities include: BIM strategy and implementation; asset information management; technical data management; document control; GIS; and configuration management.
He is a Chartered Engineer – prior to joining Crossrail he was Rail Director for a major global consultancy working on many UK and international rail projects. Starting as a Graduate with London Underground, Malcolm has over 35 years of experience in the design, construction and maintenance of large-scale transportation projects around the world, with a particular emphasis on railways and metro design.

Malcolm Taylor – "Head of Technical Information" for Crossrail

Title: Delivery of a Major Infrastructure Project with BIM

Main content: Crossrail is the largest construction project in Europe (€18 Billion) and BIM is an integral part of the design, delivery and future operation. Our current BIM strategy is to maximize the life-cycle utility that can be achieved from the advances in modeling technology linked to databases of information, so the future operator/maintainer will manage the railway assets effectively and efficiently.
The organizational needs for data and information in large infrastructure programmes such as Crossrail change and develop throughout the various phases of the project life cycles. We have developed a common data environment and management system that is used by all designers and contractors to help create two Crossrails – the physical and the virtual – that will ultimately be handed over to the railway operator and maintainer.
The rapid technology advances that have been made in the past few years continue to play an increasingly important role in how Crossrail creates, manages and exploits the use of data.

Main topics:

- The scale and complexity of Crossrail
- BIM strategy
- Sources of information
- What BIM looks like
- Challenges and lessons learned

Learning objectives:

- Information lifecycle in practice
- Importance of rigorous processes and procedures
- How to exploit changing technologies

Tomohiko Yamanashi has a Master of Urban Design degree from the University of Tokyo, which he acquired in 1986. That same year he joined Nikken as an assistant architect.
The winner of numerous awards, his latest being MIPIM Asia's Special Jury Award in 2009 for Mokuzai Kaikan. Mr Yamanashi domestic portfolio is supplemented by significant international experience in China and Singapore.

He is member of the Japan Institute of Architects and the Architectural Institute of Japan, and also teaches architectural design to graduates and undergraduates at the university level.

Tomohiko Yamanashi – Nikken Sekkei, Japan

Title: BIM Practice in Nikken Sekkei

Main content:
Nikken Sekkei recognizes that some changes concerned with architectural design have been brought by Information Technology.
The first change has begun with the technological innovations of design methods such as Computer Simulation.
The second change has been caused by the technological innovations of construction methods such as Digital Fabrication.
The third change has been made by innovative geometry-generating methods such as Computational Design.
Because the digital information plays an important role in all these three changes, we should change the platform to handle these digital data from tracing paper to a more suitable environment too. We believe that BIM is a precise and the only platform to undertake this role now.
This time, I will show you our design process based on this idea through some of our practical works.

Main topics:
- BIM as a platform of the Digital Design Age
- Computer Simulations and Computational Design in Nikken Sekkei
- Case Study 1 : Mokuzai Kaikan (The Headquarters of Tokyo Lumber wholesaler)
- Case Study 2 : Sony City Osaki
- Case Study 3 : Hoki Museum

Learning objectives:
- Japanese latest status quo with BIM
- Practical usage of BIM in japan
- How to adopt computer simulations in practical works

Jose Oliveira is the BIM Leader & Revit MEP Specialist for Mott MacDonald in the UK.
He is one of the pioneers Revit MEP user in Europe that was part of the first UK project to use this software.
Jose has been responsible for the implementation of Revit MEP and BIM, as well training the CAD departments of a leading consultant within the UK, promoting the benefits to use of BIM in any size and type of project.

Jose Oliveira – BIM Leader at Mott Macdonald

Title: The True Value of BIM

Main content:
In 2011, the UK government announced that any supplier wanting to bid for public sector construction projects must use BIM tools and techniques by 2016. However, according to a survey conducted by the information service NBS, the perceived expense and time commitments involved in adopting BIM technology remain the biggest barrier to greater up-take.
BIM is the process of generating and managing building data that can be used in the design, costing, construction and maintenance phases throughout the life cycle of the building.
Traditionally, during the early concept and schematic design phases of a project, 2D CAD drawings are issued between consultants and architects for design co-ordination purposes which creates untold checking, cross-checking, and red-lining of drawings, resulting in numerous revisions. With BIM, a single model of the building is produced and can be passed between the consultants, client and project team.
Remember, BIM is here to stay and so we should learn to adapt and embrace it or risk losing ground to others.

Main topics:
- Adoption of BIM
- Overall value of BIM
- The impact of BIM in MEP coordination
- Internal Business value of BIM
- Project Value of BIM
- Player Value of BIM

Learning objectives:
- Why to use BIM
- The benefits of using BIM
- Applying BIM to any project size

Jonathan Lock, BIM Leader at Arup's Building Engineering London office

Jon is an associate structural CAD and BIM Leader specialising in multi-disciplinary building design. He has led the structural Modeling teams on a wide variety of commercial projects and has successfully collaborated with signature architects and clients. These include Heathrow Terminal 5, Leadenhall Tower, National Museum of Qatar and The Pinnacle Tower.

He has considerable experience working on complex structural steel, concrete and refurbishment projects, and coordination and integration with architecture and building services. Jon has a comprehensive knowledge of 3D Modeling and a collaborative working process.

Several of Jon's projects have been recognised within the industry, receiving awards and special commendations, including the application and understanding of BIM to design the stunning National Museum of Qatar. He has a particular interest in developing the use of BIM as a downstream deliverable with manufacturing and construction collaborators. Jon leads the development and application of BIM within Arup's Building Engineering London office.

Jonathan Lock
BIM Leader at Arup's Building Engineering London office

Title: BIM at Arup – An evolution in engineering design

Main content:

What does BIM means to Arup? Building Information Modeling (BIM) Is not a single product, service or software solution. It is a descriptive term for the technologically advanced, collaborative and information – centric processes now being used to design the built environment.
It is characterized by use of models that represent databases of geometrical and spatial data along with embedded properties, specifications, performance criteria and other associated computable data.
The models are typically manipulated and interrogated in a 3D environment, but the underlying data can be used to describe the building in many different ways throughout the life-cycle of design, construction, operation and subsequent refurbishment or recycling.
The term "Total Architecture implies that all relevant design decisions have been considered together and have been integrated into a whole by a well organized team empowered to fix priorities" – Ove Arup, Founder, Key Speech 1970.

Main topics:

- Transition from 3D – London Olympics Aquatic Centre
- Working in 3D with Contractors – Leadenhall building
- Working with existing buildings
- The point cloud
- Towards Facility Management
- Delving into the data
- What about after....?

Learning objectives:

- What is BIM
- Benefits of BIM
- Understanding the process
- Understanding the deliverables

Francisco Reis has a degree in Civil Engineer, Specialisation in Structures, at Faculdade de Engenharia da Universidade do Porto, and a MBA at Católica Porto Business School and ESASE Barcelona. Designer and Project Coordinator, with experience in several specialties as Process, Mechanical Equipment, Foundation, Structures and Hydraulics. Focus on Water Treatment and Wastewater Treatment Plant design in several countries such as Portugal, Morocco, Romania, Mozambique, Angola and Algeria.

Since 2007 is the responsible manager for the implementation of the Building Information Modeling for Project and Construction.

Member of the BIM Fórum Portugal and the GT-BIM of Plataforma Tecnológica Portuguesa para a Construção, Portugal.

Francisco Reis
Engineering and Project Department at EFACEC
Engenharia e Sistemas, Environment Unit, Water Division.

Title: BIM at Efacec – The new paradigm

Main content:

Being one of the greatest Portuguese players in the MEP area, Efacec recognizes that innovation is a key point in the continuous growth that the company has either at a national as well as at an international level.

BIM potentiates the development of more economical solutions and allows us to have a control management of all installation, creating value in all steps of the processes.

The change in the paradigm requires the involvement of people and the creation of new processes.

BIM shall change the present way of working generating a collaborative model and avoiding the fragmentation of the process of the project, which results in loss of productivity.

The easiness of management of all information as well as the easy visualization of the solutions are the advantages that anticipate the decision making and allow that the designers and builders to be focused in valued tasks and not in routine processes and verification, which spend resources and are time consuming.

Main topics:

- Impact of BIM in the Organization
- Value of BIM
- Workflow in Design and support to the Construction
- Design to Construct in a collaborative way

Learning objectives:

- Costs reduction in Project using BIM
- Advantages of using BIM in MEP solutions
- BIM a way to support and manage the Construction
- The value of BIM to the Client

Working as BIM-manager for the Peab group. Peab is the biggest contractor in Sweden and operates in the Nordics except for Denmark with four business sectors: Housing, Infra structure, Industry and Property development.
Before this I have a history as a construction engineer and BIM-consultant in the housing sector with projects mainly in Sweden but also in Denmark and Saudi Arabia.

Andreas Furenberg, BIM Manager at Peab group

Title: BIM-strategy for a construction company, from board decision to end user implementation

Main content:
Peab is a construction and civil engineering company whose ultimate guiding principle is total quality in all stages of the construction process. In 2009 the board took the decision to put focus on BIM as an important technology for business development in the future. From that day a project started to identify possibilities and a strategy for implementing BIM in Peab. The report that came out from that work made the foundation of what we still are working on and probably will continue working for a couple of years.

The presentation will include business cases that made the board take the decision to go forward with BIM and what are the BIM processes in Peab today. It will also include the future strategy and the obstacles we have met on the way and that we can predict. I will also share some good practices for a successful implementation that they learned from their experience.

Main topics:
- Implementation
- Business case
- Simple is still difficult
- BIM-strategy

Frank Haase holds a Master's Degree in Structural Engineering and is a licensed Professional Engineer and has worked in the industry for more than 16 years. Frank started to work for Webcor Builders 10 years ago and has worked as a Project Manager on the general contracting side as well as a Project Manager for the self-performing concrete division. For the past 6 years Frank Haase has developed integrated model based processes at Webcor Builders and built a 20 person VDC team that delivers integrated model based processes to all projects at Webcor Builders. Webcor has implemented an integrated model based supply chain process that replaces conventional processes in the preconstruction and construction phase of Webcor's projects. This disruptive change meant that existing processes of estimating and scheduling had to become one integrated process that feeds off the same data base.
In addition all downstream processes such as procurement, buy out and production control would rely on this data. What made the change even more complex is that design processes and subcontractor processes are affected as well which made the change an intra-company change. To develop and implement this change Webcor Builders developed a unique VDC team consisting of Project Managers, Detailers, Superintendents, Process engineers, Software Engineers and Data Analysts. This team works as a centralized service department servicing projects in the company. The replacement of conventional core operational processes required people inside the group to change as well as the people outside of the group.

Frank Haase, P.E. LEED AP, Director of Virtual Building at WEBCOR BUILDERS (San Francisco, CA)

Title: Implementation of integrated 5D VDC processes

Main content:
5D integrated processes integrate in a balanced way different types of know-how and services. 5D transforms standalone services of cost estimating, scheduling and constructability review into a seamless value rich solution. The implementation of 5D integrated processes is a cross functional change. The installation of this process is carried out by a cross functional team that operates unconfined by departmental requirements dedicated to develop and define the new integrated solutions. In a second step the new process is rolled out transforming the cross functional team into a service team. This service team provides direct services in the form of deliverables such as cost estimates, schedules, constructability reviews and indirect services in the form of training for departments and project teams.

Main topics:
- 5D process overview
- Implementation strategy
- Cross functional team selection
- Corporate sponsorship
- The role of visionary leadership

Learning objectives:
- What is cross functional change
- What are the benefits of the 5D cross functional change
- What are the difficulties
- A possible solution

António Meireles has a degree in Civil Engineering, an MBA in Corporate Management and currently he is developing his PhD thesis. He has developed several internal studies and experiences on the best approach to implement a BIM in a traditional and geographically dispersed company. He is focused on the improvement of the construction industry through the development of knowledge, as well as efficient and innovation driven processes. He empowers stakeholders of the Construction Industry to use BIM and lean construction methods so as to deliver integrated construction services more efficiently and more productively.

He is leading the process of collaborative construction revolution and BIM implementation at Mota-Engil and in Portugal by being the BIMForum Portugal and PTPC BIMWorkGroup Coordinator.

António Ruivo Meireles
BIM Manager at Mota-Engil and BIMForum Portugal Coordinator

Title: An advanced integration of BIM in the construction process

Main content:

Welcome to a truly 5D BIM! This class showcase a BIM based physical and economic planning and control system inspired in advanced management methods. BIM has the potential for truly changing the way people plan and communicate and manage resources.

The forecast of the cash flow of a site depends of a good work scheduling. A good work scheduling depends of the quality of information available, like the quantity takeoff. BIM can be the ultimate database of the site, which supplies all the information that supports the decision and the definition of scenarios.

Advanced construction management methods, like line of balance and earned value management, are powered by BIM. On this presentation will be shown how a BIM can be integrated on a construction company and how it can support the site management as a service.

Main topics:

- 5D process overview
- Implementation strategy
- Benefits of a BIM implementation
- BIM as a service
- The future

Learning objectives:

- Not reinventing the wheel
- BIM is not expensive
- What are the difficulties
- BIM is collaboration

Ju Lee is a key player in the BIM-FM arena and is a BIM and GIS Program Specialist for the owner, USC, via USC Capital Construction and Facilities Management. Trained as an architect, she is responsible for helping develop a new BIM platform extending BIM to lifecycle management by linking data-rich as-built models to existing O&M and FM software platforms. Collaborating with BIM consultant ViewbyView, software developer EcoDomus and architect, Urban Design Group, for the donor and developer, LucasFilm Ltd., she embarked on an experimental endeavour looking for ways to harvest useful data collected during the design and construction process to develop BIM as an integrated repository and portal for managing information throughout the life cycle of a building. USC's efforts represent a proof of concept for extending BIM to operations and they were the worldwide pioneers in this endeavour.

She also played a large part in developing the BIM Standards for USC with their major stakeholders using standard data formats such as COBie, and industry standards like OmniClass and the National CAD Standards. In anticipation, USC is now leveraging their experiences with BIM for smarter building operations and to expedite the close-out process.

She holds a Bachelor's Degree in Architecture from the University of Michigan, Ann Arbor, a Master's Degree in Architecture from Sci-Arc, Los Angeles, and a Master's Degree in Construction Management from USC, Los Angeles.

Ju Lee Kang, USC Facilities Management and Capital Construction Development, BIM and GIS Manager, Los Angeles, USA

Title: 3D BIM-FM Portal: Extending BIM into Lifecycle Management

Main content: A Building Information Model has been proven to deliver immense cost savings and production efficiencies in the construction industry since its recent widespread use around the world. A hidden potential of this technology is yet to be leveraged and that is the "I" in BIM, i.e. how does one harvest the potential of the richness of "Information" that reside within the model to continue realizing economies of scale this same information can provide during the operational phases of a facility? Knowing that the most costly phase of ownership of a building during its life cycle occurs not during its construction phase but rather during its operational phase, how can a BIM assist owners, technicians, managers and occupants achieve these cost savings, energy efficiencies and level of occupational comfort by fully utilizing technologies that exist within their fingertips and that which are in the realm of possibilities?

We will explore how a large institutional owner has begun to utilize BIM to increase efficiencies in their building (micro scale) and campus (macro scale) management of assets and day to day operations. We will also be looking at their development of a new BIM Portal that extends BIM to Lifecycle Management by linking data-rich as-built models to existing O&M and FM software platforms. Lastly, we will take a quick look into what it takes to embark on this endeavor and ponder on its capabilities.

Main topics:

- Integration of Asset Management (CMMS), Document Management (EDMS) and Energy Management Systems (EMS) with BIM
- Introduction to the 3D BIM-FM Portal
- Exploration of 3 Real Life Use Cases in a Facility's Day-to-Day Operations
- How, Who, What and When does data get collected into a model?
- The role that the implementation of BIM Guidelines and use of industry standards like COBie, OmniClass and the National CAD Standards play in making this happen

Learning objectives:

- Understand the full capabilities of a Building Information Model and what this means to institutional level owners and their expectations
- Explore the process and coordination involved during construction in preparing models for lifecycle management
- Grasp the importance of BIM standards in the execution of projects for future stakeholders

Tomo CEROVŠEK, Ph.D. is a Vice Head of Department of Civil Engineering at the University of Ljubljana, Slovenia. He works as a Professor in engineering communication, descriptive geometry, digital design, process Modeling, concurrent engineering and BIM. As an author he has published several papers on BIM, his Framework for BIM Technological development at Advanced Engineering Informatics, is the most downloaded paper at publisher's respective journal for the last two years.

Dr. CEROVŠEK is also the CEO and founder of Ljubljana University Incubator's technology transfer spin-off CERTUS, Reliable Systems for Integrated Engineering and Facility Management, l.t.d. focusing on BIM applications and consultancy delivering leading edge model based methodologies to the field on new large scale building projects, technological projects and FM. His incremental technology transfer through real-world BIM pilot projects demonstrates the best practices to the investors, AEC practitioners, and contractors with proven gains in quality, time and cost reduction.

His professional and research interests include project communication and information systems, 5D BIM, integrated practices, generative structures and the use of BIM Lifecycle: from Sustainable Design to Facility Management. He has participated in several EU projects as lead researcher and technical coordinator. He is a member of IEEE, CIB and technical committee for standardisation.

Tomo Cerovšek
CE Department Vice Head, University of Ljubljana
CEO & founder of Ljubljana University Incubator spin-off CERTUS, Slovenia

Title: The True Value of BIMBuilding?

Main content:

Understand the potential of building information models (BIM) – which are developed by architects and engineers for the design, analysis, visualizations and documentation during pre-construction, construction and post-construction phases. As construction project evolves the BIM content is changing. The changes in post-construction that support and result from Facility Management (FM) should be stored in As-Managed BIM that extends As-Built BIM to make use of BIM FM Systems.

Implement BIM FM system that enables a complete overview of plots, buildings, stories, spaces and building systems, along with daily operational data. An overview of major steps to a successful implementation of BIM FM systems shall be given, covering: planning, design, implementation and support. The benefits that shall be addressed are: improved information access, transparency and facility condition, lower costs of ownership and environmental impacts.

Make use of BIM FM Systems to deploy European standard for facility management EN 15221 on all three levels: (1) Strategic, (2) Tactical and (3) Operational sustainable FM. Key indicators include operational costs, preventive, corrective and breakdown maintenance, facility condition along with reduced use of materials, impacts on the environment, including sustainability indicators: energy and water consumptions, CO_2 footprint and use of chemicals.

Envision BIM FM SaaS centralized repository of documentation, advanced model based support for maintenance planning, breakdown reporting, task and work-order management, along with supply chain management and diaries with complete control of information – linked to locations in the BIM. BIM FM integrates BIM and databases, which together, enable integrated planning, maintenance, reporting and reduction of total cost of ownership of buildings. Advanced BIM FM features that must be provided, are: model based space management, tenant management, move management, reporting with technical management and technological maintenance of systems and installations.

Get familiar with large scale case-studies: a Hospital project and University Project with over 300 buildings. The presentation will provide an overview of the working systems, details on the developed BIM libraries, integration issues and practical implications.

Main topics:

- What is the total BIM Lifecycle (From As-Designed to As-Managed BIM)
- How to make use of BIM for FM (The path to the benefits of BIM for FM)
- How to implement standards with BIM FM (Key Performance Indicators)
- What are the state-of-the-art FM features (Integrated BIM FM SaaS)
- How does BIM FM work in practice (Case studies: Hospital & University)

Arto Kiviniemi has a Master of Science in Architecture at Helsinki University of Technology (Finland) and PhD in Civil and Environmental Engineering at Stanford University (California, USA). Since 1996 Arto has developed Integrated Building Information Modeling (BIM) both in Finland and internationally. In 1997 Tekes (Finnish Funding Agency for Technology and Innovation) invited Arto to lead the national BIM R&D programme "Vera – Information Networking in the Construction Process 1997-2002" consisting of over 160 projects with the total budget of 47 million euro. The programme created the foundation for Finland's position as one of the leading countries adopting BIM in the industry. In May 2010 he moved to his current position at the University of Salford in UK, where he in autumn 2011 started UK's first BIM master's programme, MSc BIM and Integrated Design, which already has gained a prominent position both in UK and internationally. Currently he is a member of the International Technical Advisory Group and buildingSMART Korea Advisory Committee.

He has presented over 100 keynote and invited lectures in international seminars and conferences around the world since 1996. For his international merits in developing integrated BIM Arto received the FIATECH CETI Outstanding Researcher Award in March 2009 and the Order of the Knight of White Rose of Finland in December 2012

Arto Kiviniemi, Professor of Digital Architectural Design at the School of Built Environment in the University of Salford

Title: How to include BIM in the future curricula of AEC professionals?

Main content:

BIM is a rapidly growing area in the AEC (Architectural, Engineering and Construction) Industry and will cause fundamental changes in the professional roles, work processes and business models. Achieving the full benefits the new technology requires clear understanding of the BIM concepts and information flows in the process. However, most educational institutions still teach their students based on the old document based paradigm. Including BIM is not easy because of the existing curricula are extensive, there is no room for additional topics and in some cases changing the content might risk the accreditation of the courses. The presentation will discuss the challenges and possibilities and use the development at the University of Salford as a potential example.

Main topics:

- Challenges and possibilities in implementing BIM in education
- Viewpoints of architectural design and technology
- What should be different in BIM based education and why?
- Where are we at the University of Salford?
- Conclusions

Learning objectives:

- Effects of BIM in the industry and its impacts to required skills
- Why would BIM require different education
- What should the educational institutions consider when implementing BIM in their courses

Heritage and Architectural Rehabilitation	**BIM and Point Clouds on Architectural Re-habilitation** Barbosa, M.J.; Mateus, L.; Ferreira, V. Portugal FA-UTL arcHC_3D
	BIM for Heritage and Renovation Counsell, J. United Kingdom Cardiff School of Art and Design, Cardiff Metro-politan University
Architecture and Engineering	**BIM to Energy: Extending BIM for Multi-Model Domain Tasks** Katranuschkov, Peter; Liebich, Thomas; Guruz, Romy; Weise, Matthias Germany; Germany; Germany; Germany TU Dresden; AEC3 GmbH; TU Dresden; AEC3 GmbH
	Modelling of the reinforced concrete of a building in BIM: Analysis of its contribution for a more efficient measurement and bud-geting processes Sousa, Hugo D. C.; Couto, João Pedro; Meireles, António Ruivo Portugal; Portugal; Portugal MSc Student at the University of Minho; Univer-sity of Minho; Mota-Engil
	Practical implementation of BIM on NEW-TON Structural Engineering Projects Lino, José Carlos Portugal NEWTON – Engineering Consultants
	BIM implementation and cost-benefit anal-yses: an architecture and engineering case study Lacerda, Nuno; Tavares, Vanessa; Venâncio, Maria João Portugal CNLL, Lda.
Facilities Management	**A Portuguese Case Study of the use of BIM and cobie for Facility Management** Sousa, Fernando; Mendes, Jorge M.; Meireles, António Ruivo Portugal; Portugal; Portugal Instituto Superior de Engenharia do Porto;Insti-tuto Superior de Engenharia do Porto; Mota-Engil Engenharia
	BIM for Facilities Management: Lifecycle Requirements Management tool for Thermal Conditions – WebRoomEX Forns-Samso, Francisco ; Laine, Tuomas Finland Granlund Oy

Implementation and management	**BIM implementation: an experiment integrating practice, theory and didactic** Moura, Norberto C. S.; Giacaglia, Marcelo Eduardo; Lara, Arthur Hunold Brazil Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo
	Introductory concepts on BIM – The importance of Information Mêda, P.; Sousa, H. Portugal Porto University School of Engineering
	BIM – A Global Implementation Vasconcelos, Alexandre Portugal Broadway Malyan
	BIM adoption: a demanding option Lima, João; Leal, C. Gustavo; Leal, Carlos Portugal; Portugal; Brazil Bimtecnologias, Lda.; FlowProject, Lda.; CARLOS LEAL – Engenheiros Consultores LTDA
BIM Technology	**Taking Building Information Modelling Mobile** Miskimmin, Iain United Kingdom COMIT/ Bentley
	BIM-based e-procurement and the PLAGE R&D project Costa, António Aguiar; Grilo, António Portugal; Portugal Instituto Superior Técnico, Technical University of Lisbon; Faculdade de Ciências e Tecnologia, New University of Lisbon
	Coding with IFC: some practical steps Regateiro, Francisco; Costa, António Aguiar Portugal Instituto Superior Técnico, Technical University of Lisbon
	Development of 3D interfaces for mobile BIM applications Martins, João Poças Portugal University of Porto

Education	**Collaborative Intelligence in the educational context of BIM** Marques, Sandra France École Nationale Supérieure d'Architecture de Toulouse/ Laboratoire de Recherche en Architecture (LRA)
	Crossrail and Bentley Information Management Academy Miskimmin, Iain United Kingdom Bentley / Crossrail
	Educational activities for the teaching-learning of BIM Barison, Maria Bernardete; Santos, Eduardo Toledo Brazil University of São Paulo
Heritage and Architectural Rehabilitation	**BIM and Point Clouds on Architectural Rehabilitation** Barbosa, M.J.; Mateus, L.; Ferreira, V. Portugal FA-UTL arcHC_3D
	BIM for Heritage and Renovation **Counsell, J.** United Kingdom Cardiff School of Art and Design, Cardiff Metropolitan University

BIM and Point Clouds on Architectural Rehabilitation

Barbosa, M. J.; Mateus, L.; Ferreira, V.
Portugal
FA-UTL arcHC_3D

1. Introduction

The goal of this article is to outline the importance of BIM and it's relation with point cloud based surveys, terrestrial laser scanning and automatic digital photogrammetry, on Rehabilitation Projects.

BIM (Building Information Modeling) is a process of information management through a 3D model. There are multiple BIM software like Graphisoft Archicad, Autodesk Revit, Bentley Microstation, Digital Project, that allow interpreting the life cycle of a building in the nD dimensions.

To intervene in an existing building we need to know is history, characteristics, materials, we need an accurate survey. The new technologies of Terrestrial Laser Scanning (TLS) and Terrestrial Digital Photogrammetry (TDP) rapidly and accurately capture and measure the geometry of a building [1] and its characteristics like colour, texture or anomalies location.

Photogrammetry studies the processes by which one can accurately relate the geometrical information of an object with a digital image through measurements performed on photographs [2,3].

TLS is a technology that uses laser light to obtain the coordinates of a large number of points in an almost continuous and near real-time [4].

3D Point Clouds (PC) represents the first possible product of the TLS and TDP survey. Once they are processed and oriented into a final point cloud model (PCM) they represent a rich source of the building data.

2. The Process Between PCM and BIMThe Process

The best way to work PCM data is still being researched, these models are not usually directly usable in most 3D applications, so they have to be converted into polygons models (mesh), NURBS models (non-uniform rational BSplines), or CAD models (wireframe models or solid models) by a process commonly referred to as 3D surface reconstruction.

The workflows to obtain a 3D model from 3d data are transversal to multiple disciplines. In Architectural area most of the 3D modeling workflows use the 3D data as a geometric reference to guide the Modeling process. The "Reverse engineering" area is pointing a semi-automatized way to do this process, where CAD software tool (e.g Geomagic, Rapidform Xor and 3DReshaper software) recognises the shape (of a PCM or a NURBS model) and semi-automatically transforms the model into solid surfaces. The general problem of this, applied to BIM, is that it generates a mass model and when you import it to a BIM software it doesn't recognise the mass as elements and their related parameters.

There are also some architectural software plugins like Scan to Bim and Point Cloud Feature that have an automated recognition and placement of elements (like walls, columns, pipes). However the specialists due to the high-cost and low benefit of such tools don't usually use them.

The input data for the BIM modeling can be directly or indirectly used from point clouds. In some BIM software like Autodesk Revit we can directly import the PCM to the Platform, in other software like Graphisoft Archicad it is best to import 2D sections as images obtained from mesh models or point cloud models and use it as a reference.

From the contact with specialists we infer that the most used workflow in BIM is the use of PCM or surface models as reference to trace over, producing a smart 3D model by placing the parametric shapes over the point clouds.

From the review of the current state of art (books, published papers and case study reports), there is a lack of description of the methods and workflows used to create 3D models from data. Its modeling logic and standards are still emerging, even in most respected and recommended standard references for heritage documentation like "Recording, Documentation, and Information Management for the Conservation of Heritage Places"[5] and "Metric Survey Specifications for Cultural Heritage"[6] the BIM process is not discussed.

In the following case studies we were able to extract some information about workflows for creation of as-built BIM models, and structure it in three main phases: I) acquiring 3D data; II) processing 3D data; III) modeling BIM based on the 3D data.

In "Building information Modeling and heritage documentation"[7] it is explored the capacity of BIM to document and monitor building performance parameters through a case study, the Batawa Project. The BIM model is constructed and managed using Autodesk Revit and Autodesk Navisworks based on various sources like TLS and existing documentation, and it incorporates quantitative and qualitative assets (e.g. historic photographs, documents).

In Arayici's [8] case study building, the Jactin house building in East Manchester, the PC data was acquired with the Riegl LMS Z210 scanner. RiSCANPro and the Polyworks software were used for PC registration and post processing resulting in PCM. This model can be converted into a mesh model using the IMMerge Module of Polyworks software and then exported to IMEdit for refining. Here cross-sections planes are created and exported to a CAD software such as Microstation Triforma where they are used as a reference to generate a BIM Model.

The use of this workflow, according to the author, increases production and understanding of virtual reality models in the regeneration projects.

In "Combining a virtual learning tool and onsite study of four conservation sites in Europe"[9] we can find case studies like the National Monument Edinburgh, Karolinum Prague or Henrietta Street Dublin where they use 3D Data (complemented with 2D data in some cases) as references to draw 2D drawings in CAD platforms (Graphisoft ArchiCad and Google Sketchup) and then use it to create a 3D model.

In Karjalainen's [10] case study of Pyhäjoki Bridge it was created a BIM model from PCM and compared the usability and accuracy of the geometric model with the PCM. It was concluded that through this workflow regarding to bridged intervention the mistakes in design work decrease and the production management and project control are more reliable.

In most cases there is a lack of technical specifications regarding the processes.

3. Rehabilitation and BIM

The workflows between PCM and BIM can be used for the virtual reconstruction of the building, but also for documentation of the architectural object in study.

A Rehabilitation Project is an iterative and recursive process based on data that is in constantly changing the course of the ongoing work. BIM allows changes during the working process supporting a non-linear workflow that suits the Rehabilitation Project needs. It also enables collaborative teamwork allowing different specialists to work simultaneously with the same basic model resulting in a rapidly evolving process [11].

The level detail and data interpretation of the BIM should be adequate to the intervention type requirements. There can be different levels of detail in a 3D graphic representation model just like there are different known levels of documentation survey precision [12, 3].

In resume, BIM is a "coordinated, consistent and always up to date workflow improved in order to reach higher quality, reliability and cost reductions all over the design process. Even if BIM was originally intended for new architectures, its attitude to store semantic inter-related information can be successfully applied to existing buildings as well, especially if they deserve particular care such as Cultural Heritage sites"[1].

4. Final Remarks

The workflows to use BIM and PC are still being worked out, nevertheless it is quite obvious that it is a powerful union when we think in merging an efficient way of managing the project information with the most accurate survey data.

Specialist's opinion is consensual: the relationship between PC and BIM is an area of research opportunities that could allow a higher quality, reliability and cost reduction in the design process of existing buildings.

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BIM for Heritage and Renovation

Counsell, Jam
United Kingdom
Cardiff School of Art and Design, Cardiff Metropolitan University

1. Introduction

The UK government BIM task group has a vision described as Level 2 BIM. In this vision a focus on COBIE is sensibly working back from the end user need for long term asset management. This poses a dichotomy between very long term lifecycle information management via COBIE, and relatively short term information snapshots in BIM for specific new build or renovation. Here it is argued that there will remain additional challenges so long as BIM is assumed to be primarily for new construction, and that while COBIE may be purposed for data transfer to asset management systems, it is less likely to prove either broad enough for wider Construction Information Management nor specifically for Heritage BIM in the long term conservation and management of heritage buildings. In support of this organizations such as Atkins in the UK [2] state they are seeking to integrate GIS, BIM, and construction documentation.

2. Problem Identification

So much of construction is not green field. It is significant that independent assessment by economists of the outcome of the Sydney Opera House BIM trial (SOH) projected potential productivity increases of 5% across the whole Australian Facilities Management Sector, via the appropriate use of BIM on existing buildings coupled with benchmarking and procurement improvements. [3] Yet there are additional desirable dimensions to Heritage BIM (HBIM) that these SOH studies did not address. Apart from a few pilot initiatives, mainly focused on important heritage buildings, little work has yet been published in using BIM for the retention and management of existing heritage. While some reports have outlined success in these pilots, detailed information is not published for independent study, let alone the HBIM models or subsequent measured data of performance following refurbishment. The statement "BIM has not been tested that much in renovation projects yet, although the importance of renovation and restoration is remarkable within the total volume of western construction sectors" remains appropriate.[4] In their study of the Aalto Helsinki Architecture School (HUT) restoration project Penttilä et al noted that "the information structure of renovation projects differ remarkably from the structures of new buildings. The models, which for instance were developed in the Finnish ProIT project ... do not necessarily fit for renovation purposes", and went on to advise that "it is essential to note, that in renovation projects the inventory model does not contain just geometrical data, but it has to be able to contain all the design project related information which is needed in the process, and by all project participants." Penttilä et al describe how Solibri was used to analyze different ways of extracting and reporting information about the model. "The attributes of the model components were used to demonstrate various possibilities to manage renovation related data, such as historic, time-related facts, observed condition, preservation status etc." [ibid] Whereas in the SOH application existing databases contained the relevant information and the challenge was to unite them via the IFC model, in the HUT case the IFC objects needed to be tagged with restoration and renovation specific data to permit the sorting and retrieval required. Boeykens recently held that "while most Building Information Modeling applications are targeted to current architectural practice, they seldom provide sufficient content for the recreation of historical models". He also identified the need for "an information database, collecting facts and accuracies" for "visualization of color-coded 3D models, depicting the accuracy of the model" [5].

These are areas where further research and moves towards standardization are required. The SOH trial tested the heterogeneous use of loosely coupled associations between the IFC based model, GIS data, and other disparate databases using web technologies, in order to create that fully integrated model that contains all the heritage renovation project information. Both the SOH and HUT pilots found it difficult to create an existing building 'BIM' using the usual digitized paper record drawings. In one instance the SOH project obtained a very high accuracy of surface data for performance simulation by using 3D laser scanning. Murphy et al [6] state in their Dublin pilot that while "the laser survey can only record the surface of the object; construction details behind the surface can be detected from historic data, thus producing a full 3D and orthographic vector survey of an object or building." Murphy et al outlined an HBIM data capture and modeling process that relies on best fit of parametric objects to point cloud. In the relatively symmetrical and repetitive conditions of Georgian Dublin this may produce useful models, if not fully accurately representing settlement, shrinkage and change over 200 years. However as discussed below, other heritage forms such as the Tower of London lack the clearly identifiable boundaries between elements that suits such a process.

3. Results and Discussion

The author has now, with colleagues in Cardiff School of Art and Design (CSAD), started a project, in partnership with the Welsh Government Heritage body, which aims to develop an open and integrated set of modules for Heritage BIM over the next two to three years, centered on a current case study, but as an exemplar for best practice. This has identified a need to integrate: 3D GIS ; open-BIM; repeated LIDAR surveys; sensor data that extends beyond current BMS practice towards responsive smart building data; and analysis of occupancy and use; building upon and integrating a range of relevant experiences gained from previous projects. These projects and experiences began for the author leading development of BIM for Westbury Homes between 1990 and 1994, integrating full 3D modeling of buildings and sites, above and below ground, using Gable and Moss interoperable for what-if comparisons, cost prediction, drawing synchronization, and management information systems. [7] There were many information management frustrations despite overall success, leading to exploration of the use of 3D GIS to complement and enhance the information management gaps of 3D CAD.[8] This led directly to a 1996 commission by Historic Royal Palaces to model the Tower of London and its surroundings to centimeter accuracy. Initially we tried a parametric modeler, Reflex. However as Boeykens points out, the limitations of this approach for modeling accurately a complex of almost 100 buildings with a palimpsest of alterations and unique shapes and forms proved insuperable. So we used a combination of Autocad and 3DS. This lacked any ability to link attribute and other HBIM data.[9] Thus we then explored the use of GIS (Mapinfo), with bespoke extensions using its API, to manage geometry and heritage data and to generate interactive 3D VR modeling.[10]

Other projects continued this focus on HBIM. [11] Involvement with international colleagues in the VEPS Interreg Project between 2003 and 2008 explored alternative LIDAR focused approaches to web based collaborative modeling, communication, annotation, and discussion.[12] A 'sub-plot' within the same project explored ground based LIDAR for heritage building recording, modeling and interpretation of historic antecedents. [13] Gillard Associates were commissioned, following a 2007 international design competition, to re-design Atlantic College's aged student housing stock to align with the UK Code for Sustainable Homes level 4.

CSAD were funded to monitor the refurbished accommodation block through the seasons, for comparison both with the as-existing blocks and with those predicted results from the simulation process. [14] Extended monitoring and simulation forms part of the current project. The author worked with Johnson Controls for several years from 2005 exploring methods of automatically monitoring people in their use of space in order to optimize space provision. While there are clear issues of privacy, some techniques could be anonymous, and behavior remains a particularly large variable in many aspects of building usage including energy.[15] Regularly recorded LIDAR, sensor and activity data in particular creates very large datasets that will prove an increasing challenge to store analyze, manage and update.

4. Conclusions

Morris et al claim there to be a current over-emphasis on the new-build aspects of BIM (design and procurement only) that needs correction to ensure "life cycle support - the model supports the FM data over the complete facility life cycle from conception to demolition, extending current over-emphasis on design and construction phase."[ibid] Heritage BIM, it is argued here, involves many more dimensions and some particularly large spatially referenced datasets that requires interoperability over very long periods between a wide range of tools, including: BIM; 3D GIS; performance simulation and analysis; document and image management; and interactive visualization that distinguishes between accurate and speculative interpretation. Since data capture and processing is usually the first hurdle to overcome for longer term information management, it is recommended that open standards are rapidly developed for geo-referencing data, not just as currently in X and Y, but also in Z, and that these should be translatable between IFC and GML.

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Architecture and Engineering	**BIM to Energy: Extending BIM for Multi-Model Domain Tasks** Katranuschkov, Peter; Liebich, Thomas; Guruz, Romy; Weise, Matthias Germany; Germany; Germany; Germany TU Dresden; AEC3 GmbH; TU Dresden; AEC3 GmbH
	Modelling of the reinforced concrete of a building in BIM: Analysis of its contribution for a more efficient measurement and budgeting processes Sousa, Hugo D. C.; Couto, João Pedro; Meireles, António Ruivo Portugal; Portugal; Portugal MSc Student at the University of Minho; University of Minho; Mota-Engil
	Practical implementation of BIM on NEWTON Structural Engineering Projects Lino, José Carlos Portugal NEWTON – Engineering Consultants
	BIM implementation and cost-benefit analyses: an architecture and engineering case study Lacerda, Nuno; Tavares, Vanessa; Venâncio, Maria João Portugal CNLL, Lda.

BIM to Energy: Extending BIM for Multi-Model Domain Tasks

Katranuschkov, Peter[1]; Liebich, Thomas[2]; Guruz, Romy[1]; Weise, Matthias[2]
Germany
[1]TU Dresden, [2]AEC3 Deutschland GmbH

1. Introduction

The advance of Building Information Modeling (BIM) in recent years expedited its use in a growing number of AEC projects and practical tasks. Along with that, various problems that had been addressed earlier in narrower scope had to be reconsidered in search for adequate industry relevant solutions. Such problems include collaborative work support, change and version management, life cycle sustainability and so on [1]. Continuously extending the use of BIM-based working and the related needs for BIM-based interoperability of more and more specialized AEC tools in various building construction subdomains showed also that (1) a global all-encompassing model for all data in a construction project is neither realistic nor practical target, and that (2) BIM data typically have to be combined with other kinds of construction related data in order to be efficiently applied in real AEC tasks [2].

This paper addresses the issue of BIM extension for such multi-model domain tasks on the basis of work done in the EU project HESMOS for the development of an energy-enhanced BIM framework (eeBIM) enabling the integration of multiple needed resources (climate, occupancy, material data etc.) and the interoperability of a number of energy analysis, cost analysis, CAD, FM and monitoring tools in an Integrated Virtual Energy Lab Platform [3].

2. BIM Extension Approaches

In many cases, available BIM models like the current IFC2x3 or the new IFC4 model [4] do not provide sufficient data to fully support data exchange requirements and tool interoperability for a particular domain. Therefore, while the re-use of already available BIM data is of undisputable benefit with regard to team work coordination and life cycle information management, the integration of BIM with external information resources is an essential issue to solve for the achievement of an efficient BIM-based work process. However, before actual modeling and/or implementation work starts, the appropriate approach for the targeted BIM extension framework has to be decided.

In principle, three such approaches are to be considered: (1) Extending the BIM schema, (2) Extending the BIM data, and (3) Using a Link Model.

Extending the BIM schema(s) with new concepts, attributes and relations to accommodate the needed external information resources relates to standardization work done e.g. within the BuildingSMART initiative. Such model extensions are already available for various domains like building services, structural analysis, construction manage¬ment etc. It requires achievement of consensus among the involved parties and leads to a new version of the standard. Technically, it is the most efficient way to extend BIM functionality but it also has some major drawbacks: develop¬ment work typically takes very long time, the model becomes increasingly complex and consequently more difficult to use in software, domain applications are overburdened with data of other domains they do not actually need, and – last but not least – external data originating from other sources or even other industry branches (e.g. meteo data, geo data, various supplier data etc.) are difficult to maintain up-to-date and to keep under control.

Therefore, this approach is preferable mainly when large, re-usable domain tasks are targeted, the required data is within the competence and control of the AEC industry, and schema changes remain compatible with earlier model versions to ensure fluent imple¬mentation. It is less advisable for tasks involving extensive use of external modeling data and ad-hoc situations.

Extending the BIM data by using existing interface facilities in the model without changing the model schema provides a different, undisruptive approach. Within IFC various such extensions are possible using the flexibility of the IfcRelationship subclasses, the IfcProxy concept and especially the IFC property set mechanism allowing simple or add-on attribution to various standard BIM entities. The benefit of this approach is the easy to agree upon and imple¬ment specification of the needed external information resources and the avoided change of the standard model itself. However, the latter is also one of its main drawbacks because the use of proxies and property sets has relatively low semantic depth and requires agreement between applications in terms of rules or regulations that are not part of the model, an issue of arguable sustainability. Another drawback is that the expressiveness of the available interface extensions can only cover scenarios where the needed external data are of manageable complexity. Thus, this approach is only applicable when the use of external modeling data is minimal.

At last, using a separate Link Model as a bridge between BIM and non-BIM data can provide for greatest generality, modularity and implementational scope. It does not require changes in the BIM schema and the external models used and it guarantees maintenance of each model within its own domain (e.g. climate data maintained by meteorologists). Furthermore, it provides for greater semantic depth, helps to handle almost arbitrary data structures and enables a clear interoperability strategy. Its essence is in capturing the relationships of BIM data to external information sources within a separate data structure, the Link Model, and resolving these relationships by means of model management tools at run-time. Drawbacks are the difficulty regarding the maintenance of the Link Model, the need of additional link model management services, some run-time performance deficits due to the increased data complexity, and possible consis¬tency problems in the rare case of overlapping multi-model data. Thus, whilst possible for any multi-model problem, the Link Model approach is most useful where (1) a large amount of external information resources is needed and these resources have non-AEC origin, and (2) where a flexible platform for a set of (exchangeable) software tools is sought. A typical case here is the development of a Virtual Lab for energy-efficient building design and life cycle management.

3. Energy Enhanced BIM

Development of an energy enhanced BIM framework (eeBIM) was undertaken by the authors in the frames of the EU project HESMOS on the basis of the Link Model approach outlined above. The objective of the project was to close current gaps between existing data and tools from building operation and design so that to enable efficient lifecycle energy performance estimation and decision-making by developing an Integrated Virtual Lab platform for energy and emission studies in PPP projects. One thing which became clear already at the outset was that realization of the envisaged eeBIM framework requires (1) Filtering the BIM data to a model subset tailored to the needs of the domain, (2) Inter-linking the filtered BIM data with the external model data required for the various necessary computations, and (3) Mapping specifications and tools for the transformation of the BIM-based data from/to computational application models (energy simulation model, energy monitoring model, cost model). Here we discuss only the use of the suggested Link Model approach in the HESMOS project. Details on the developed overall framework are provided in [3].

Basically, five types of non-BIM data are considered in the eeBIM framework. These are: (1) Climate and weather data, (2) Extended, detailed organized material data providing the needed material properties for sophisticated energy analyses, (3) Energy Templates providing ready-made configurations useful for early design decisions, such as space use, occupancy profiles, default element construction etc., (4) Pre-fabricated components with their specific energy-related properties from digital supplier catalogues, and (5) Sensor data from Building Automation Systems. Each of these types of data requires specific binding to the BIM data as shown in table 1 below. However, the table also shows some of the difficulties that have to be overcome in the practical implementation of the Link Model. Thus, along with the trivial case of 1:1 correspondence between the BIM and the external data (as e.g. between climate data and IfcBuilding) more complex cases need to be resolved, too, such as the association of one external data item to a group of BIM entities known or not known in advance (e.g. material data associated to typed building elements, but also occupancy profile associated to a grouping of rooms that is not available as such in the IFC model) or the inter-linking of nested BIM objects to external entities (e.g. material properties to material layers in IfcWallStandardCase). In addition, there are various situations where geometric algorithms must be considered, such as the estimation of spaces which are bounded by outer (facade) elements, the estimation of the facade elements as such etc. For such cases, a set of open model management services called BIMfit have been developed which facilitate, along with the Link Model, the BIM-based multi-model integration.

Table 1 – Overview of multi-model links in the eeBIM framework.

Multi-model issue	Related BIM concepts	Link type	Multiplicity
Climate data	Building; Facade	Explicit; explicit or algorithmic	1:1; 1:N
Material data	Building element (and the related subclasses)	Explicit (nested assoc.)	M:N
Energy templates	Building; Storey; Space zone; Space	Explicit (grouping assoc.)	1:1 to M:N
Pre-fab. components	Building / Distribution element (and subclasses)	Explicit (grouping or nested assoc.)	1:1, 1:N, M:1
Sensor data	Space (external, internal); Building element	Explicit (algorithmic for locations)	1:1, N:1

4. Final Remarks

In the preceding sections we presented the main issues regarding the development of an extended BIM-based multi-domain framework. Using the eeBIM framework of the HESMOS project, work on an Energy MVD has now begun within buildingSMART. This work is based on the overall MVD concept and the new mvdXML development enabling the formalization of partial models as well as the definition of certain model consistency rules [5]. The eight scenarios developed in HESMOS are thereby considered as starting point for the definition of exchange requirements, such as client requirements, BIM to energy analysis, BIM to operational costs etc. [6]. The expected result is an Energy MVD which shall be used for the certification of CAD applications that will support the export of relevant, sufficient and reliably verified BIM data for energy analysis and simulation tools such as EnergyPlus, DOE-2, NANDRAD etc.

5. Acknowledgments

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Modeling of the reinforced concrete of a building in BIM:

Analysis of its contribution for a more efficient measurement and budgeting processes

Cortês de Sousa, Hugo Daniel[1]; Couto, João Pedro[1]; Ruivo Meireles, António[2]
Portugal
[1]University of Minho, [2]Mota-Engil

1. Introduction

This work results from research activities within the scope of the Master's Thesis in Civil Engineering underway in the University of Minho and carried out in partnership with two companies, Mota-Engil Engineering and Software House Construsoft.

It is commonly recognized the growing trend that the industry has experienced over recent decades as a way to increase competitiveness, improve performance by updating its practices, increase customer satisfaction and also its profit [1]. This way, the implementation of information technology has allowed the development of new methods of work in all sectors of economy, including the civil construction sector. Yet, it is noted that the construction industry is one of the least efficient in the adoption of information technologies [2].

BIM (Building Information Modeling) is a process with a huge potential for industrial success, promoting new habits and methods of work, always in favour of the efficiency improvement, growth of productivity and competitiveness.

Building, as a multi-organizational and multidisciplinary process, requires the intervention of several fields of expertise, becoming quite dependent on the sharing and exchange of many complex data and information. Thus, it is essential that there is accuracy, ease, efficiency and speed of communication and exchange of information and data between team members [3].

It is through this philosophy, in other words, it is through this need for a paradigm change in the implementation of projects of different fields of expertise that the BIM is currently recognized as an important development in the industry of architecture, engineering and construction (AEC). Currently, at the national level, it is possible to find some practical examples of application of this methodology, although some resistance has been experienced, which has contributed to the slow adoption of these new procedures. One way to promote this methodology is to include it in the educational processes and in the training of civil engineers, as professionals from the construction area will increasingly need to acquire knowledge and skills to relate and communicate through BIM tools [4].

According to Sinergia (2012), "BIM is an integrated process that stores and streamlines the exchange of information design, construction and exploration between the various stakeholders of the construction cycle, creating models with high potential for decision making, in various stages of preparation, construction and maintenance an enterprise. These information models that represent all the physical and functional characteristics of the building allow the visualization, simulation and analysis in a phase well before the existence of the building, creating a new dimension: the virtual." [5]

Therefore, as main advantages of introducing this technology in construction processes, the following may be highlighted: increased productivity, lower costs and processing times, management improvement and project planning, better coordination and communication among stakeholders and increased compatibility between the various fields of expertise, anticipation of potential problems and / or opportunities and greater energy efficiency and sustainability in construction.

The elaboration of this work is expected to foster, through the Tekla Structures software, the potentialities that the use of BIM technologies gives to the construction industry concerning the improvement of management aspects and budgeting resources, thereby contributing to achieving higher levels of perfection throughout the life cycle of the construction process. It is increasingly needed to acquire new work habits, through the use of all the potential that BIM technologies offer, in order to boost competitiveness, and to improve the productivity and effectiveness of civil construction.

2. Method

The work developed in collaboration with the company Mota-Engil and the Software House Construsoft has as main objective of contributing, with the use of BIM technologies, to improve the quality of construction, making the BIM an indispensable tool in the construction industry, making it an asset for all phases of the construction process – from the initial conception to the phase of the demolition of the building. The task developing on BIM specifies on Modeling a building already constructed, which required data will be provided by the company Mota-Engil. With the provision of the building model, it is intended to model the reinforcement of concrete using Tekla and the subsequent measurement and budgeting of the resulting quantities, as well as the extraction of the drawings of the construction details for subsequent validation by comparing these results with the data provided by the company. Therefore, as a methodology to adopt for the elaboration of the study, firstly, the model building in IFC format will be transposed to the Tekla Structures software. Then, after the analysis of the building, the next step is the Modeling of the reinforcement concrete of the building. After this phase, there is the extraction and budgeting amounts of the reinforcement concrete. Finally, the interoperability model will be analysed by exporting the model to other software, such as Archicad and VICOSoftware.

3. Preliminary Results and Discussion

As first results, the operational ease that BIM technologies allow to introduce on construction projects may be highlighted. There is a higher quality and informative veracity. The reduction of work and time required in preparing and reading projects due to the introduction of BIM technologies is noticeable. These technologies make it easier to read, analyse and manage projects.

Still at an early stage, BIM allows, in a more facilitated and explicit way, highlighting potential errors of construction or incompatibilities in constructive details that could only be detected after the construction of the buildings.

The images presented in Figure 1 are preliminary results of this work. These images enable a more holistic view of all the work and all the constructive details. It is possible to analyse detail by detail and evaluate the final conditions of the work still at a preliminary stage. It is also possible, and that will be studied at a later stage, a quick and direct extraction of the quantities and costs of materials to be used, in this case, in the reinforcement of concrete. Thus, it is possible to control the errors and reclaim the costs and times in constructive processes during the project phase.

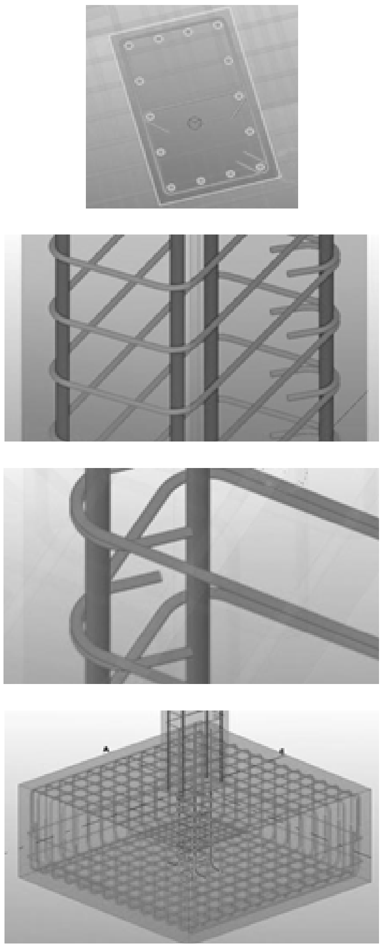

Figure 1 – Detail of reinforcement in constructive elements

4. Conclusions

At first reading, it may be noted that the entire process elapsed within the expected period of time. The adaption of BIM is to be positive and the first results obtained are to be favourable. It is possible to identify the ease of interpretation of the projects with the BIM technology and, so far, there is a greater understanding and analysis of all the details of reinforcement of constructive elements.

As a result to be achieved, it could be expected that the measurements and budgeting for reinforcement of concrete are increasingly fast, intuitive and efficient processes, due to the large existing coordination in these BIM processes.

5. Acknowledgments

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Practical implementation of BIM on NEWTON Structural Engineering Projects

Lino, José Carlos
Portugal
NEWTON – Engineering Consultants

1. Introduction

Building Information Modeling (BIM) is widely known as an important innovation in the industry of architecture, engineering and construction, being associated with a paradigm shift in the way that engineering design is accomplished [1]. Structural design has benefited from the potential of this concept, particularly on the interaction with automatic calculation software, on the automatic generation of drawings and also on quantity takeoff operations.

In the current Portuguese context, we can already find several BIM case studies in architectural and engineering design offices. However, many obstacles have contributed to a relatively slow adoption of these new procedures. Nevertheless, it is agreed that professionals in the construction field are increasingly becoming aware of the necessity of acquiring knowledge and skills to collaborate and communicate through BIM [2].

This work presents some practical examples of the BIM-related implementation efforts in the design procedures of NEWTON´s engineering office activity as structural and foundations designers. In addition to highlighting the mature aspects of the current state of technological development of BIM methodology in the design process, this work also focuses on our views regarding the main barriers on the full implementation in design practices.

2. Advantages and Barriers

BIM is one of the emerging trends that certainly will introduce new methodologies in structural design production and documentation, supporting virtual building over a digital model that allows architects, engineers and builders to better design and plan construction and operation. Thus, BIM is a set of policies, processes and interrelated technologies that provide a methodology for managing the building design and its data, over the entire life cycle of the building.

Several studies have been conducted to examine the benefits of implementing BIM. However, there are practical barriers and limitations, which are restraining the widespread adoption of BIM [3]. Many constraints are technical in nature and have been gradually addressed by software producers, by researchers and by organizations. Nevertheless, the biggest challenges of the implementation of BIM are mainly centered on people and on organizations, since the adjustments in procedures and communication flows, accountability and trust are not easy to change [4].

3. Case Studies

Through a brief presentation of structural projects modeled in BIM and carried out by NEWTON's engineering office, we illustrate the most developed aspects of our current state of implementation, while mentioning the main barriers to its full implementation.

NEWTON has often chosen to carry out structural design in BIM, even in cases where architects and other stakeholders have not adopted the same methodology. In such cases, the modeling is performed over the drawings provided by the several actors, whatever the format in which they are available.

According to our recent experience, it starts to be increasingly common that, in the early stages of the project, the surveying is automatically imported to the model, thus enabling the automatic quantification of earth movement volumes and the interaction with the team of landscape architecture. We also found that the automatic extraction of plans, sections, elevations and selected details greatly contribute to simplify the production of drawing parts of the process and to deliver the project on time, while minimizing errors/incoherencies (see Figure 1a).

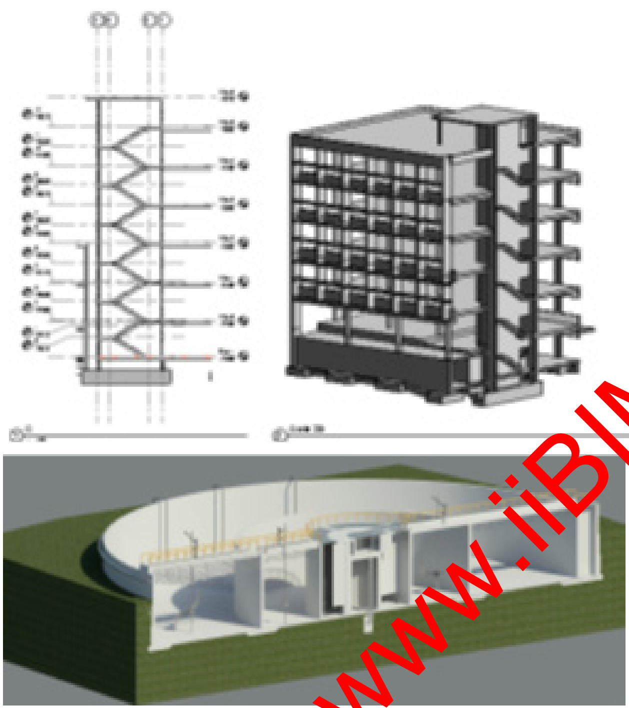

Figure 1 a) Automatic drawing extraction – INESCII b) Collaborative work – ETAR do AVE

In several case studies particular emphasis took place on the collaboration between the structural designer and other design stakeholders (see Figure 1b) [5]. One of the main advantages obtained with the dynamic sharing of the model, was the optimization and focus on required solutions, in order to encompass all the designer's needs. The interference Architecture and Engineering between the projects was early verified and resolved. In many of these collaborative uses of BIM models, the three-dimensional visualization and rapid extraction of construction details lead to an easier analysis and validation of common solutions. Concomitantly, it was possible to include the 4D timeline construction phases in the model.

Finally, in several of these case studies, the complexity of formal shaping minded by the architectural team raised a number of interoperability difficulties with the structural modeling software (see Figure 2a, b) [6]. Consequently, it implied redefinitions in order to be identifiable by the structural analysis software.

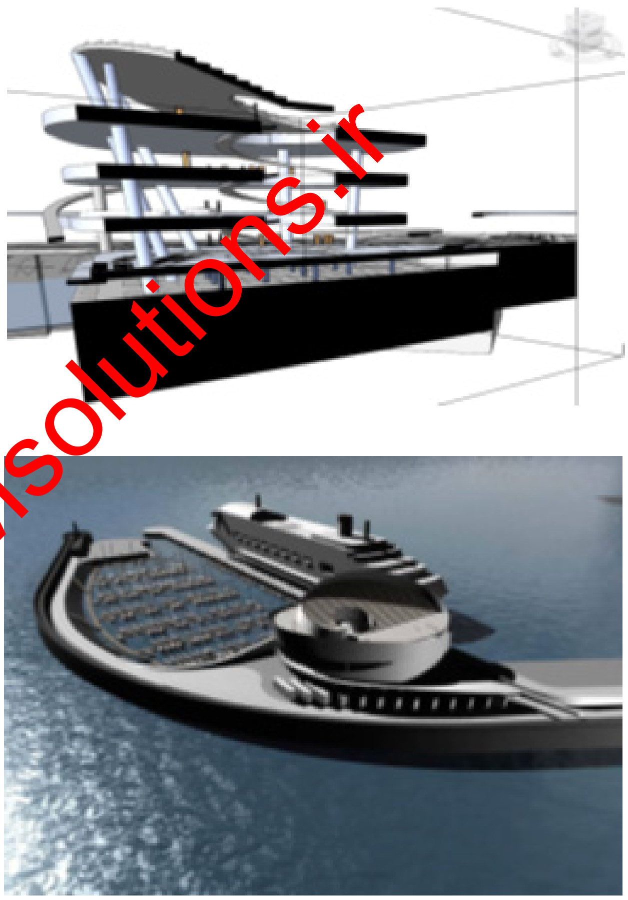

Figure 2 a, b) – Complex shape modeling – Leixões Cruise Terminal Building

4. Conclusions

Undoubtedly, the communication between architectural and engineering participants over the life cycle of a building has received a boost with the potentialities of BIM, which enhances the collaborative work merged with information technology to a new level. BIM is no longer regarded as a mere technological and software change, being also seen as a change in procedures and mentalities.

The practical implementation of this methodology among structural designers is starting to become evident, still having, however, some difficulties related to the initial investment, to the learning curve, to ownership rights, to the difference between maturity states of the participants in a project and also to the increasing complexity of the structural modeling with complex shapes, among others.

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BIM implementation and cost-benefit analyses: an architecture and engineering case study

Lacerda, Nuno; Tavares, Vanessa; Venâncio, Maria João
Portugal
CNLL, Lda.

1. Introduction

This paper aims at demonstrating the effectiveness of BIM implementation in one medium size architecture and engineering company, conducting a cost benefit analysis during its application period from 2006 to 2012. The costs and consequent return will not only be listed, but also analyzed. Implementation costs include software and hardware acquisition, staff training and project time increment. Benefits will comprise increase in profit (the company benefit) and hourly rate decrease (gain to the client).

2. Materials and Method

In literature review some practical case studies and BIM methodology assessment have been presented [1 5]. A small number of papers introduce some companies´ implementation processes, some presenting the methodological approach [6], and others an economical assessment [7-9]. This study intends to present both analyses. This study is based on data from one single case study; therefore, results may not be representative. Accurate data gathering was possible as the company has its process certified by ISO 9001 since 2006.

2.1 BIM implementation

The implementation process was conducted in the following ten steps:

1. Firstly, a company internal analysis was conducted in order to evaluate its positioning both at national and international level, internal staff competence and alignments and misalignments with market evolution tendencies. This action intended to evaluate the company´s competiveness in the future global market.

2. After, the previous study, a market research was performed with the purpose of identifying key actors in architecture and engineering international stage. Furthermore, the undertaken methodologies were studied and different software solutions were considered. New software and hardware was acquired. In this case, Revit Architecture was the selected program.

3. Subsequently, the team was trained in order to introduce BIM methodology in procedures and to qualify staff to use the new software. Two workers attended an exterior course and an external expert was hired to conduct in the office, training to the architecture department.

4. Next, the team developed a pilot stage as the first case study in which both methodology and software were applied. Some procedure errors were identified and problems were detected.

5. Based on the problems identified in the pilot stage, the architecture department had internal advanced training in the office and engineers attended the initial course. Revit structure and MEP were purchased.

6. Applying the knowledge acquired previously, the company´s template was improved and the library was augmented. Both are constantly under development.

7. Following, BIM software and methodology was expanded to the engineering department being the collaboration tools and centered storage file further tested.

8. A second pilot stage was performed with a pack of six school centers project in which architecture and engineering projects were developed using BIM methodology.

9. A third pilot stage was performed with a "Parque Escolar" school. Different software was used for measurements and the budgeting phase (ProNIC platform, according to the client´s request). Some integration and communication problems were identified.

10. Finally, all the projects were developed using BIM methodology though the maturity of the methodology applied is far from it is envisage.

2.2 BIM implementation cost

Implementation costs were divided in four categories: software and hardware acquisition, staff training and some initial increment in project time. Staff training represents the major cost as it stands for 1/3 of all costs. Software and hardware weighs roughly the same (27% and 26%) and hardware acquisition and/or upgrades are the minor fraction, with 14% of total investment costs. The value of costs during the studied period totalizes approximately 240.000 €, nearly 1/4 in year 0. The decrease tendency in costs is inverted when the number of workers increases (2007-2008 from 5 to 8 workers; and 2009-2010, from 8 to 10 workers). Besides, when under qualified staff is hired, the training cost is relevant. It is important to highlight that some investment in MEP and structure software was made without being implemented, thus representing a cost without return.

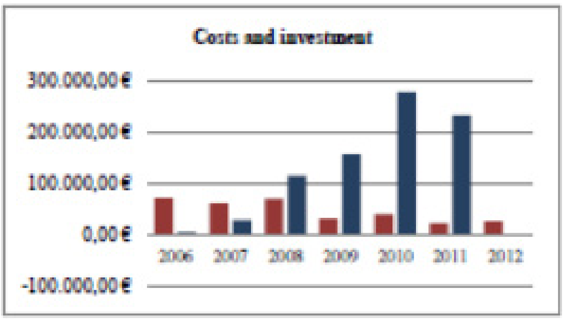
2.3 BIM benefits

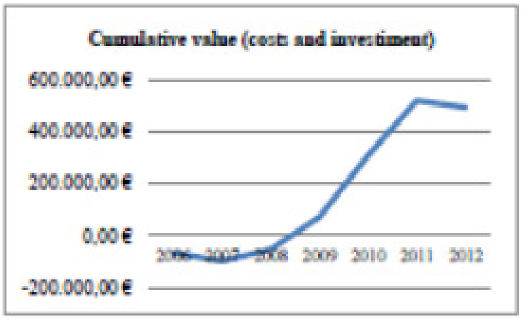
The identified benefits were: reduction of project related error and execution time, positive impact of projects, continuously updated projects, increase in productivity and BIM added value, reduction of project time, improvement of delivered service and better communication between all stakeholders. However, most of these benefits were considered intangible, being proposed two different criteria: decrease in hourly rate (a direct benefit to clients) and increase of profit imputed to BIM implementation in relation to reference year (2006).

year	costs				benefits		total costs	total benefits	total
	software cost	hardware cost	training cost	increase in project time	benefits for the company	benefits for the client			
2006	7.458 €	3.757 €	[illegible]	[illegible]	3.940 €	0 €	69.738 €	3.940 €	-65.798 €
2007	4.364 €	10.790 €	[illegible]	[illegible]	7.048 €	20.496 €	60.447 €	27.544 €	-32.903 €
2008	13.599 €	5.293 €	[illegible]	11.354 €	8.570 €	106.061 €	69.094 €	114.631 €	45.537 €
2009	5.915 €	3.714 €	[illegible]	0 €	13.630 €	141.587 €	30.029 €	155.217 €	125.188 €
2010	19.331 €	6.148 €	[illegible]	0 €	152.370 €	125.179 €	39.349 €	277.549 €	238.200 €
2011	7.024 €	[illegible]	5.600 €	0 €	74.450 €	157.972 €	21.193 €	232.422 €	211.229 €
2012	6.923 €	[illegible]	8.960 €	0 €	-82.630 €	81.444 €	25.688 €	-1.186 €	-26.874 €
	64.614 €	33.715 €	77.809 €	62.791 €	177.378 €	632.738 €	315.537 €	810.116 €	494.579 €

3. Results and discussion (cost benefit analysis)

The assessment was based in the values expressed in table 01. The larger amount of costs occurs in the three first years, with a decreasing tendency. However, BIM costs persist as staff training and equipment and software are always in constant actualization. Most of the benefits calculated occurred in the year 2010 with the largest team (10 elements) and highest percentage of team dedication to projects (59% in 2009 and 58% in 2010). The return of the investment was in the year 3, being 2009 the turning point.





4. Conclusions

The most relevant conclusion that can be withdrawn is that BIM implementation requires a high initial investment and constant annual costs and at least a 2 or 3 years are needed for the investment to payback. The economic context since 2012 is reflected in company´s BIM benefits, as resources (team and equipment, including software) are sized for a bigger market demand. As the BIM structure is more expensive, part of company´s losses is imputed to BIM implementation, expressed by a negative value of benefits. This highlights the importance of adapting the team to market needs (reduction in staff) or expanding market (by an internationalization process) to match company productivity installed capacity.

5. Acknowledgments

Authors want to thank CNLL, Lda. for providing all data in this study.

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Facilities Management	**A Portuguese Case Study of the use of BIM and cobie for Facility Management** Sousa, Fernando; Mendes, Jorge M.; Meireles, António Ruivo Portugal; Portugal; Portugal Instituto Superior de Engenharia do Porto;Instituto Superior de Engenharia do Porto; Mota-Engil Engenharia
	BIM for Facilities Management: Lifecycle Requirements Management tool for Thermal Conditions – WebRoomEX Forns-Samso, Francisco ; Laine, Tuomas Finland Granlund Oy

A Portuguese Case Study of the Use of BIM and COBie for Facility Management

Sousa, Fernando[1]; Mendes, Jorge José de Magalhães[1]; Meireles, António Ruivo[2]
Portugal
[1]Instituto Superior de Engenharia do Porto, [2]Mota-Engil Engenharia

1. Introduction

The area of the Facilities Management (FM) is based on a set of information from a project created in phases of design and construction, which will be used in the exploration phase. The FM applied in the operational phase becomes increasingly important in the universe life cycle of the project due to its important role in the sustainability of the operation of the building coupled with an efficient use of resources and the maintenance tasks, providing owners and facility managers reductions in operating costs and carbon emissions, as well as providing workplaces safer with efficient operation of the facility. Some work areas of FM are preventive maintenance, corrective maintenance, space management, efficient energy management, cost control, forecasting expenditures, etc..

The Building Information Modeling (BIM) can be used to demonstrate the entire building life cycle, including the processes of construction and facility operation [1]. BIM can also be defined as the process of generating and managing building data during its life cycle [2]. Beyond the geometric information, BIM also contains information about the relationships between spaces, quantities and properties of building components, geographic information, etc...

FM is an activity that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process, and technology and data information. To be effective it must obtain from different parties and different kinds of software as much information as possible in a standardized way.

The Construction Operations Building Information Exchange (COBIE) approach is to enter the data as it is created during design, construction and commissioning, see Figure 1. Designers provide floor, space, and equipment layouts. Contractors provide make, model, and serial numbers of installed equipment. Much of the data provided by contractors comes directly from product manufacturers who can also participate in COBIE [3].

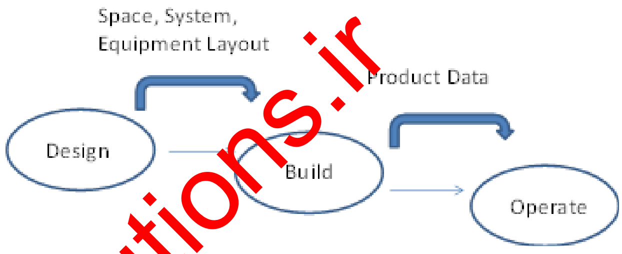

Figure 1 – COBIE Process Overview (adapted from [3])

The COBIE specification denotes how information may be captured during design and construction and provided to facility operators. COBIE eliminates the current process of transferring massive amounts of paper documents to facility operators after construction has been completed and eliminates the need for post-hoc as-built data capture and helps to reduce operational costs [4].

To make possible a standardization of COBIE an international panel of experts, facility operators, construction managers, and asset managers participated in a project under the auspices of the Development Team of the National Building Information Modeling Standard (NBIMS-US). This work report the requirements analysis that led to a pilot implementation standard, specifications for the pilot implementation standard, and the creation of an Information Delivery Manual with process maps used to link user requirements into the Industry Foundation Class (IFC) model [4].

The objective of this work was to investigate the technological process between BIM, BIMSERVICES and COBIE for Facility Management using a pilot construction project in Portugal.

2. The Approach

Instead of the current practice of the storage of papers, books, drawings, and discs usually provided by the constructors, the BIM would allow the designer to transfer the building information to the owner providing the owner with a priceless collection of information about the building generated since the projects conception. As a result, the BIM can enhance the future use of a building and its information, benefit the end user with life cycle analysis, and even change the way maintenance is accomplished by making building information readily available, accessible, and understandable.

It is intended to use the software ARCHICAD (ARCHICAD is an architectural BIM CAD software developed by Graphisoft) to develop the pilot construction project. Using the input attributes and properties of components in the model file to be exported in Industry Foundation Classes (IFC), which is an open specification for the BIM data that is exchanged and shared via the various participants a project of construction of a building or facility management using the Model View Definition's which is the standard methodology and format of documenting the requirements for implementing the software for the IFC standard, based on data exchange, adopted by building SMART International.

As the ARCHICAD cannot directly exported to spreadsheets COBIE specification, ARCHICAD produces output data (BIM models and data IFC) with capabilities to be easily converted into COBIE documents with the use of free or commercial ones. COBIE is a data format for publication in a spreadsheet from a subset of the information model of a building, focused on the delivery of information not geometric building modeled.

The company AEC3 developed the BIMSERVICES suite of command line utilities using the TNO IfcEngine for the ERDC and it is freely distributable. The suite includes:

- Transform1 : to interoperate between IFC, ifcXML and other representations such as COBIE2 and HTML. Configured using XSLT files;
- Filter1 : to reduce an IFC model by filtering out selected objects and relationships;
- Compare1 : to compare tow IFC models from the project downwards;
- Compliance1 : to check an IFC model for compliance against a regulation or requirements. Configured using IFC Constraint models, and user specific dictionaries.

This work used a construction project developed using the ARCHICAD software. After exporting the IFC data files, the AEC3 programs converts IFC data files into spreadsheets with COBIE specification as a basis for use in FM and to be Computerized Maintenance Management Systems (CMMS) compliant format, see Figure 2.

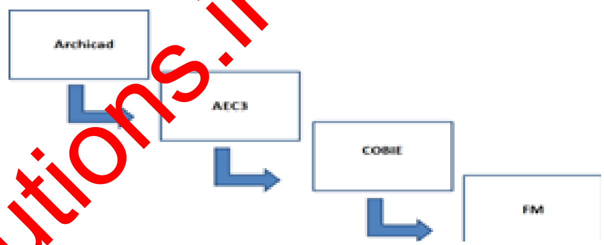

Figure 2 – Technological process

3. Conclusions

We noted that the practice of FM in Portugal is not taking advantage of the availability of technologies such as BIM, for effective and efficient management of projects.

It is important to change habits and make practical use of the proposed approach. Owners of works, designers, contractors and facility managers should use the entire life cycle of a project to create integrated information to make an effective FM.

It is important, therefore, that they occur in the future the following requirements:

- The projects must use BIM technology during design and construction;
- All the architect/designers must share their BIM's or format them in an IFC format;
- The BIM models must have data generated from construction phases, to provide information for the FM;
- The use of COBIE is a cornerstone for the BIM success.

The integration of BIM, BIMSERVICES and COBIE will increase the value of the data and also provide savings of time and money in the operations of the building throughout its lifecycle.

4. Acknowledgments

A special thanks to the availability and enthusiasm of the company Mota-Engil for this project.

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BIM for Facilities Management:

Lifecycle Requirements Management tool for Thermal Conditions WebRoomEX

Forns-Samso, Francisco; Laine, Tuomas
Finland
Granlund Oy

1. Introduction

Despite the increasing interest to leverage building information modeling (BIM) for facilities management and operations (FM&O) there is still misunderstanding how current practices can benefit from the use of BIM in FM&O. More is still to be investigated about the current facility management processes, practices and how BIM adoption fits in the overall information management of the facility lifecycle. The applications of using BIM for FM&O are vast, and perceived value studies confirm the benefits and uses in the operational phase [1]. Web-RoomEX is a tool developed for the facilities management module in the context of the FP7 industry driven research project HESMOS. HESMOS's goal is to integrate different existing CAD, Building Automation Systems, eeTools (energy efficient) and Facility Management tools by building up an Integrated Virtual Energy Laboratory (IVEL). The IVEL is a web-based platform that can be used during design, operations and refurbishment/retrofit [2]. This paper presents the main functions of BIM-based tool WebRoomEX for Requirements Management of thermal conditions during the operational phase. WebRoomEX benefits the user for easy visualization, monitoring and controlling of energy related thermal conditions.

2. Requirements Management

A common issue in constructed buildings is the significant difference in design performance compared with the actual performance of a facility. Most commonly criteria used in design do not realistically reflect how the building operates in real life. Consumption reporting is usually given for the whole facility with insufficient information for managers to know where most consumption is taking place. These practices limit the role of facility managers in controlling and monitoring the facility and ultimately reducing energy consumption. The most common issues are high indoor temperatures, incoherent set point values for heating and cooling temperatures, building automation systems not working properly, heating and cooling functioning at the same time in the same zone and strong emphasis on reactive maintenance. All these issues lead to high energy consumption, complaints from the users, reduced lifecycle of the equipment and high volume of maintenance work [3]. Requirements management is an important sub-process in design, construction and operations that keeps track that the client quality standards set in design are maintained and updated throughout the whole facility lifecycle, especially in the operations phase. In practice however, client requirements do not follow a systematic way of being managed throughout the project and often information is lost during the different construction processes causing facilities not operating accordingly the initial quality standards [4].

3. WEBROOMEX

WebRoomex is a tool developed for requirements management of thermal conditions throughout the whole facility lifecycle. It is the upgrade web version of the desktop application RoomEX [5]. The web based solution allows the user easy way of monitoring and controlling thermal conditions of the building from any location with internet access. WebRoomEX web services can import IFC 2x3 files created in the design phase, updated during construction to be used in the operations phase. WebRoomEX interface visualizes the building in a 2D floor plan view, preferred view by facility managers, enabling the user easy detection of issues related to thermal conditions of the building. The interface consists of three main functionalities described below.

3.1. Spaces

The space functionality contains the target and simulated values for cooling, heating and supply air flow rate for each space of the building. In addition, measured values icon has real-time sensor data related to minimum and maximum temperatures, minimum and maximum CO2 concentrations and minimum and maximum humidity percentage. The values are represented in different colours for easy visualization.

3.2 Space Groups

The space group functionality contains the technical system service areas such as heating, ventilation and air conditioning. The spaces classification is colour coded and contains information such as room code, name, area and volume. The other function is the air conditioning space groups that contain information about the service area for the air handling units (AHUs). The space groups are classified by zones that define the spaces, area and volume for air conditioning units. The colour coded visualization of the different zones is critical for facility managers to know what spaces belong to which zones for maintenance purposes.

3.3 Comparisons

The comparison functionality is the most important function in WebRoomEX and allows the user to compare and visualize the differences of simulated and measured values against predetermined target values. The simulated values are retrieved from energy simulation software RIUSKA. Target value setting strategy starts in the design phase and it is validated and maintained in the operational phase. Target values represent good performance of the building conditions and can be determined by user's experience or building codes. The comparison feature illustrates a colour differentiation for the spaces that exceed a 5% percentage difference with the target values as shown in Figure 1. This option allows the facility manager or end user to rapidly focus in the room that are not functioning accordingly with the target temperature values. The comparison with actual measured values from a web service connection with the building automation systems, allows the user for immediate action to solve a maintenance issue. In addition, these functionalities support green lease initiatives that encourage owners, tenants and occupants engagement in the building performance providing real time reporting of performance metrics such as heating and cooling temperatures.

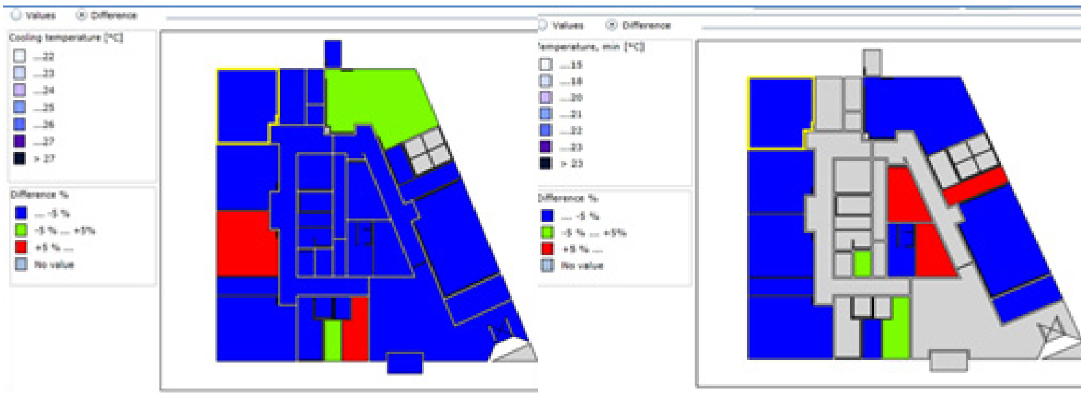

Figure 1 – COBIE Process Overview (adapted from [3])

4. Conclusions

WebRoomEX is a BIM-based tool developed for requirements management of thermal conditions throughout the whole facility lifecycle. WebRoomEX improves the work of facility manager by given performance information related to thermal conditions such spatial air flow rates, heating and cooling temperatures. The possibility for the facility manager to visually compare by each space target values with actual performance allows rapid detection faulty conditions and reduction of energy consumption. Most importantly guarantee that the building is performing according to design parameters. In addition, supports green lease initiatives that encourage the owner, tenants, and occupants engagement in building performance by illustrating real time information about the facility.

5. Acknowledgments

The work presented in this paper has been conducted in the context of the seventh framework program of the European community project HESMOS (n° 26088). HESMOS is a 36 month project that started in September 2010 and is funded by the European Commission as well as by industrial partners. Their support is gratefully appreciated. The partners in the project are Technische Universität Dresden (Germany), NEMETSCHEK Slovensko, S.R.O. (Slovakia), Granlund Oy (Finland), Royal BAM Group NV (The Netherlands), Obermeyer Planen + Beraten (Germany) and AEC3 LTD (UK). This paper owes to a collaborative effort of the above organizations.

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Implementation and management	**BIM implementation: an experiment integrating practice, theory and didactic** Moura, Norberto C. S.; Giacaglia, Marcelo Eduardo; Lara, Arthur Hunold Brazil Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo
	Introductory concepts on BIM – The importance of Information Mêda, P.; Sousa, H. Portugal Porto University School of Engineering
	BIM – A Global Implementation Vasconcelos, Alexandre Portugal Broadway Malyan
	BIM adoption: a demanding option Lima, João; Leal, C. Gustavo; Leal, Carlos Portugal; Portugal; Brazil Bimtecnologias, Lda.; FlowProject, Lda.; CARLOS LEAL – Engenheiros Consultores LTDA

BIM Implementation: An Experiment Integrating Practice, Theory and Didactic

Moura, Norberto Corrêa da Silva; Giacaglia, Marcelo Eduardo; Lara, Arthur Hunold
Brazil
FAUUSP Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo

1. Introduction

Although new technologies motivate changes and evolution, challenges and hard work follow them, to adapt or incorporate new resources and surpass the current stage. The more complex the technology the better is the expected results, but this requires planning, knowledge, practice and skills to take advantage from its potential. Building Information Modeling has brought a new approach to AEC sectors, changing production management and relationship dramatically, and impacting all agents involved in the process. BIM is not about doing the same thing in a new way, but a paradigm change [1] involving three fields: technology, process and policy [2].

Implementing BIM requires transformations in the design and construction chains, with antagonist reactions: amazement and despair. On the one hand, BIM figures as a powerful process to integrate the huge AEC scope, and it seems that there are no limits within its grasp. Initial amazement oftentimes turns into despair, when attempting to unveil all the necessary dimensions and complexities. Cases of success and failure have been reported, the first characterized by careful planning, investment and compromise; the latter by curiosity, adventure and lack of appropriate information.[3]. Partial BIM approaches have been said inadequate, stating that BIM must pervade the process as a whole, involving all phases of design and construction and all the corresponding participants. However, such ideal environment consists of an intricate net that can block any gradual initiative concerning practical and didactic issues.

Furthermore, modeling is the main medium to express and communicate design intent, and the lack of staff with abilities in digital 3D modeling is a significant constraint retarding use of the technology in construction industry. Efforts has been identified in some universities, for including BIM on graduate and undergraduate Architecture and Civil Engineering curricula [4] and recognizing the importance of defining strategies to introduce training, learning and teaching BIM to meet professional needs.

A contribution to the integration of theory, practice and teaching, this paper describes a BIM implementation process experiment; simulating actual architecture office conditions in methodological transition from CAD based design to BIM. The study object is a residential building, and BIM implementation process involved training, planning and experimenting with BIM to assess Brazilian representation coding and construction culture requirements.

The client previously agreed with the project experimental approach, but a schedule was agreed upon, defining five phases: (a) Concept design; (b) Legal approval; (c) Structural design; (d) Detailed design; (e) Electrical and plumbing design. In order to maintain client expectations, the design started with existing technology, applying CAD to phases (a) and (b) while training and preparing the staff for the transition to BIM. In this sense, CAD phases were planned to support BIM transition, revealing the importance of some concepts like information redundancy and layer management. Until now, phases (a); (b) and (c) have been concluded. Phase (d) has reached 85%, including Earthworks Design. Phase (e) is at the beginning. The construction is planned to start in June, 2013, and the assessment might be extended to connect BIM with construction management.

Although BIM technology was introduced after the conceptual phase, it has improved architectural results through: refinement of components connections, revision of structural components dimensions and constraining modulation to floor levels. BIM 3D model was generated from CAD 2D drawings allowing for deeper analysis, providing testing options and driving project decisions.

The study object consists of extended activities and supplies didactic activities, improving new discipline contents in undergraduate and graduate architectural courses.

2. Materials and Method

The experiment has been based on BIM Stage 1, characterizing a single-disciplinary 3D model [2], applying inductive and experimental methods to simulate CAD/ BIM transition in practical environment and conditions, as follows:

- Conceptual design: (CAD) while Planning and Training (BIM). Two parallel activities have been developed to conform to client schedule demands;
- BIM Model and Structural requirements: starting by structural components, the Architectural BIM Model provides preliminary structural objects to be revised and detailed by civil engineers;
- Detailed design: In addition to detailed architectural design documents, Earthworks has been included here, and electrical and plumbing design were planned to be procured during this stage.

2.1. Physical Materials

Based on an actual architectural design, the research primary data have included:

- The client;
- The site and its survey map: Area 1,097.00 m²;
- Architectural request: Residential Design Area = 400.00 m²;
- Project team: Architecture; Structure; Electrical and Plumbing installations.

2.2. Software

Although the follow list has been not completely used, all of the software have been investigated for choice and identified as selected: Autodesk Revit Architecture 2012 (selected); Autodesk AutoCAD 2012 (selected); Autodesk AutoCAD Civil 3D 2013 (selected); Bentley Architecture V8i; Bentley MicroStation V8i.

3. Results and Discussion

- The architectural design started at the beginning of January 2011. Phases: (a) Concept design; (b) Legal approval; (c) Structural design, was concluded after 10 months, applying CAD technology while preparing the staff for BIM technology. Combining a well-established technology (CAD) and the proposed paradigm shift (BIM) revealed a good strategy for BIM implementation in an actual scenario, maintaining the client's trust in the process by keeping up with the agreed schedule. Initial results, concerning concept design and legal approval, have profited from experience on CAD technology, in which the matter is well in hand, while allowing time for training and learning BIM;
- Benefits from the use of 3D parametric modeling for design communication in the early stages are noteworthy. For instance, structural engineers designers have had difficulties in understanding some building elements, and readiness in generating sections and views has demonstrated a useful resource, providing sections in any plane desired for this understanding;
- In regard to libraries of BIM elements, only 10% could be used without modification, 60% had to be adapted and 30% had to be developed from scratch by the user. Difficulties were found in adapting local components from basic libraries provided by vendors. The available components (loadable families) seldom fit the project demand, requiring extra work to produce the proper library. Surprisingly, system families like walls, ceilings, roofs and floors have required less effort, meeting project specific conditions;
- Production of didactic material was based on the adopted experimental process. The design is being monitored for the whole process, documenting all procedures identified as methodologically consistent, related to: standard representation recommendations, local construction systems, local construction industry components and sharing of model information among the design team. This material supplies didactic content, reformulating it into new (undergraduate) and existing (graduate) disciplines in Architecture courses. The didactic material rescued a not constructed building designed by Carlos Millan [5], an important Modernist Brazilian architect. This material was first tested on the graduate level discipline, not only surpassing the fence on BIM approaches, but also enlarging discussions on the use and role of digital models in architectural design, e.g., the added perception brought by the virtual construction of a designed, but not built building; or the impact of technology on the creative process.

4. Conclusions

Considering the huge extension, complexity and potential involved in BIM process, the present experiment corroborated approaching the matter by stages. This method allows deepening practice and theory on specific issues, but it is essential not to lose the whole system reference.

The hybrid CAD/ BIM method has succeeded in correlating production and training, but BIM is not dependent on CAD. Although CAD and BIM migration seems to be a useful procedure, it could lead to inconsistent method, transferring obsolete operations by routine, like T-Square Metaphor [6] , observed in the first CAD systems age.

This case study shows a generalist professional taking advantage from new adaptations that BIM requires, emphasizing the importance of teaching with a generalist profile instead of a specialist one.

The commitment of construction component manufacturers is fundamental to the BIM process, and we have noticed some vendor modeled components already available to architects and engineers by Brazilian manufacturers, like BIM pipe and sanitary component families, denoting a tendency that should be extended.

Awareness about BIM has become common in large firms, but not the same in medium and small-size ones. Due to the object study dimensions and characteristics, the firms consulted applying BIM technology have demonstrated no interest in integrating the design team, limiting the assessment of

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Introductory concepts on BIM – The importance of Information

Mêda, P.; Sousa, H.
Portugal
Porto University School of Engineering

1. Introduction

The following extended abstract has the main intention of exploring, from an introductory point of view, several concepts that have direct impact on BIM methodologies. The scope is the construction process, attending to all the stages, processes and stakeholders as well as the exchange needs throughout the productive chain. At this level, there are opposite requirements with very different embodiments. It is recognized that BIM methodologies have benefits for construction projects [1, 2]. They can support most of the processes developed by the different stakeholders from the early stages of design to the end of construction or even during exploration/use [3]. The ability to perform different approaches based on the same object through the use of perspectives or layers is essential for the different visions and demands, depending on the stages [4]. However, these benefits are only likely to be achieved with a tight control, domain and discipline of these processes. It is therefore essential to be aware that BIM is a technology that requires new forms and practices [5].

From this awareness rises the need to realize that BIM is not a question of modeling buildings or other structures on software applications, but it is mostly about organization, practices and discipline that constitute an essential framework in terms of information. Some of the topics that contribute to these needs will be further discussed.

2. Presentation and Discussion

2.1. Information

Information is essential to support all activities, in which modeling is no exception. In essence, there are no problems, as all the users employ the information that they find useful on their models. However, construction is not an individual activity. It is a team effort, involving several persons and organizations with distinct insights. These diverse views lead to different understandings and interpretations. Facing this, the problem is not the information itself, but it is mainly the needs in terms of organization and communication of that information. The data that is clear for one agent may not be correctly understood by other, may not serve their interests, or may even be incompatible.

There are several ways to communicate, yet on construction processes the most used channel to perform information exchange is written communication (documents, drawings, diagrams) [4]. It is not expected a drastically change on the channel used. This is not foreseen even on the most perspective and modern methodologies. It is noted that senders and receivers will always exist given the defined environment of the construction process. It remains the message to be communicated. In what concerns this subject there are properties that can be worked/improved. The challenge will be therefore, to find ways to structure the information so that, using common channels, the message can be interpreted by the stakeholders. Standard information organization, structure, processes and definitions are for that essential. The tools to undertake part of this work are the classification systems, as they organize and define the form of information. At the same time, it will be essential the definition of communication channels through the construction life-cycle, in order to prevent, parallel information production that may result in conflicts.

2.2. Standards

Standards and specially the International application ones have tried to set up and implement some main principles to assist on a clear definition of information and processes. In these fields there are several standards that give very good inputs. Others are considered key to BIM methodologies. However, their current format is pointed as not being friendly. For that reason some are being reviewed [6]. In this situation is ISO 12006-2 "Building Construction – Organization of information about construction works – Part 2: Framework for classification". This standard is the framework for the development of the previously mentioned classification systems. Its revision is essential to meet the needs of the new trends, namely in terms of Construction Elements, Systems and Life-Cycle framework. Its revision does not clash with previously developed classification systems. The scope of the standard is the definition of global level insight for information exchange, modeling, procurement and their main principles [7]. Detailed levels are not covered, as they are influenced by other standards, legal frameworks and differences of the construction process, among other specificities [8]. Portugal has developed an important work towards the standardization of information that is compatible with the new ISO framework, with the approach to the construction process performed by the designers, work owners and contractors as well as with the BIM methodologies [9]. Other ISO standards are also very important in what regards management of project information (ISO 22263) and the exchange of information within BIM applications using IFC (ISO 16739).

2.3. Integration

The implementation of BIM methodologies as described, will necessarily lead to integration. This sentence should be seen from other point of view that is, the implementation of BIM will only be successful with integration. By integration it is inferred the close relation or connection between agents, processes within the construction stages, integration of stages and connection between the tools that support construction. Given this framework, it is not reasonable to think BIM as a standalone application used by a single agent. Collaboration becomes an essential aspect and in which this technology has a central role. The ideal integration scenario is the one where all the agents are linked BIM: People, Culture and Change working collaboratively throughout the construction life-cycle stages and where all their tools communicate to produce the needed outputs. This intention may seem easy to comply, yet there are many aspects that need to be worked before becoming a reality. Some are found difficult to achieve in short term. The following topics will focus on some points that may constitute small steps towards completion.

From the technological point of view, it is possible with more or less difficulty to link all the agents within the construction process. By performing it, a common space for project delivery is materialized. Yet, rules and default organization must be established. Up scaling the organization, it is possible to define a collaborative and functional workspace where one or more tools are shared by all stakeholders to produce common outputs. This accomplishment has higher meaning for the processes involved on the design stage. Some tools produce outputs that can be read and edited by others. This allows time savings and improves the quality and compatibility of the final output. Nevertheless, there are several links yet to be performed. In what regards BIM technologies IFC should be strengthened and its use encouraged. Other examples of integration between tools that can be referred are the BIM nD challenge [10], the ability to link the production of drawing and written parts during the design phase, budgeting and planning systems as well as ERP's from the owner and contractor point of view.

3. Final Remarks

It is unquestionable that BIM is a reality that contributes to evolutions on the construction industry. CAD tools, many years ago, performed also this role. Yet, looking back, more could be performed in order to simplify some situations, like the standardization of colors, types of trace and layers. Nevertheless, nowadays BIM tools can support much more information than layer designation, colors or textures and traces. The impact of BIM methodologies is directly related with the ability to establish common rules for modeling development, standard inputs during each stage and depending on the outputs. Considering it:

- Standards and regulations have key role in what regards the definition of common rules. One of the reasons for their lack of implementation was due to the inexistence of specific tools to support them. The revision of standards must lead to their embedding and automatic implementation on tools;

- Technology offers many solutions. In this field there are two dimensions related with integration. There is the integration of the agents involved on the construction process and the integration of their tools on the process and with each other. As previous referred, the first dimension may be less difficult to comply. In what concerns the other, there are several steps that need to be taken, most of them by the software developers. A strategic roadmap with clear identification of the challenges and steps towards integration on the different dimensions is for that essential;

- The multiplicity of different skills and understandings playing different roles is a reality that it is not expected to change. Many authors identify the human skills as the greatest challenge. To overcome the current practices it is essential a revolution on the way the processes are performed. Training will have an important role. The know-how from the implementation of previous tools, like ERP's might be very useful to find ways to motivate and lead people to learn new methodologies and change the necessary practices [11].

For this to work, common language and understanding must be developed, implemented and learned. Classification systems should also be embodied on tools and with the ability to manage topics/tables like construction materials, work results and construction elements, as they are key elements for common information standards. At this level, BIM is assumed not as an evolution but as a revolution that stresses the change of practices and up scales the construction industry practices.

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BIM in Broadway Malyan – A Global Implementation

Alexandre Vasconcelos
Portugal
Broadway Malyan

1. Introduction

Founded in 1958 in the UK, Broadway Malyan has grown into a global practice with almost two thirds of its work from other countries. In the past year the company broke into Indonesia, Vietnam and Qatar. The practice has 16 offices around the world with 500+ design experts and was active in 41 countries in 2012.

Broadway Malyan is in the process of a global BIM implementation. This process started two years ago in the United Kingdom and is now taking its first steps to implementing to the rest of Europe, Middle East and Asia.

The objective of the presentation is to share the challenges and experiences of a BIM implementation at this scale.

With the British government action towards ensuring that BIM becomes the standard platform in the construction industry it was necessary to understand what this entailed meant to the company. As a leading global practice in Architecture, Design and Urbanism, Broadway Malyan has taken a pro-active approach to the validation of different methods and technological processes. As a result this has driven the commitment to implementing BIM across all the regions where Broadway Malyan currently operates.

2. Materials and method

An initial BIM implementation plan was developed, which is reviewed constantly and acts as the corner stone for the entire process. The following summary outlines the key steps within the process:

2.1. Pilot projects

The initial step was to test BIM software on projects to validate the implementation by ascertaining the benefits and challenges inherent to such a major undertaking. The experience on pilot projects gave Broadway Malyan the confidence that the technology has the potential for major benefits and serves our clients with real added value from the conception through to the life-cycle of the Building and its components. Our pilot projects relied also on the collaboration with a few sub-consultants with BIM experience to ensure that the process was properly accessed.

These lead to the Caprice Gold Hotel in Istanbul where internally we had more than one office involved and externally the Structural Engineer used the same platform resulting in the starting point of a more collaborative approach. Finally Fulham Wharf, a large mixed-use (residential lead) scheme in London saw the integration of all sub-consultants in the BIM workflow and the deployment of cloud technology for collaboration and analysis purposes. In this project we are conducting a closer comparison process on the factors like number of drawings/hours/staff with a similar project. Although this is ongoing we are for example ascertaining a reduction in production hours just above 8% and with the natural progress of the workflow we can expect to grasp more efficiency gains given that the input of information is inverse of a traditional CAD approach. The gains from the coordination are also significant but difficult to quantify at this stage. The fact is that less time results in a better quality of information, with the real benefits only coming to light on site.

Our positioning so far has been more to develop a clear picture of what can be realistic expectations from implementing BIM rather than publicizing our growing confidence and capability. With 85% of our income is from repeat business and BIM is another way to enhance delivery to our clients with greater added value to our services.

2.2. Choosing our partners

The following step was to ensure that the necessary software and hardware was in place to allow the introduction of BIM across the entire company. A strategic partnership was setup with Autodesk focusing on global licenses for BIM software, consultancy over a three year period, where the BIM implementation plan is central and access to product development teams as well as early adopter schemes. This resulted in a three year, €1.4 million deal with Autodesk including all the services outlined above. (http://www.broadwaymalyan.com/2012/12/practice-invests-1-2m-in-new-design-tools-to-enhance-client-services)

2.3 One step at a time

Having a strategic vision of the road map to achieve our goals with BIM, it is fundamental to securing the necessary buy-in from staff at all levels in the company. Given the number of resources, local legal requirements and the level of maturity of BIM in the industry, the implementation of this technology in Broadway Malyan instigates out from the United Kingdom. The reach of this implementation is then tied in to having the appropriate requisites in place for each location.

2.4 A common platform

Given the diversity of Broadway Malyan both in terms of its projects as well as the geographic locations there is a commitment to adhering to an Open BIM principle. The collaborative nature of our organization both internally and externally benefits from having a common exchange platform. This also entails the need for proper BIM protocol documentation ensuring proper processes and quality control are tied in to the projects contractual commitments or obligations. The application of Cloud technology has proven a major asset in this specific item demonstrating the added value of using the technology in our e-submission processes.

3. Results and discussion

Broadway Malyan has established a relevant BIM capacity in several offices in the UK and is currently developing this for all of the UK offices. As an example one of our larger offices (+100) has surpassed the 50% mark in terms of BIM capability. This entailed investing in both hardware and Staff skills to ensure that an effective response can be given to implementing BIM on projects from this office. Currently the BIM implementation is present at different stages of deployment in four of our major international offices with the necessary adaptation to local realities and as a result a further development of our BIM skills globally.

We are conducting an internal study to quantify the benefits of BIM in a multi-disciplinary team of sub-consultants on a project. It is our opinion that the BIM maturity we have now achieved conveys a realistic scenario to quantify benefits to demonstrate the improvement to our processes.

3.1. Our Challenges

From our experience we have found that the different level of BIM maturity globally is a major challenge:

In several instances Consultants have very little understanding of the processes that are being committed to and the scope of their participation in them.

Clients are open to the concept of BIM but do not have a grasp of its repercussions and hesitate when required to fully commit to BIM on their projects given that most of the time there is an immediate increase in cost with project consultants without understanding the vast improvements and benefits that result from its deployment further down the line.

Globally we have found that there are considerable difficulties with key issues such as:

Our presence in emerging markets, which hinders the implementation of collaborative work methods. Given that the maturity of our industry varies geographically and with it the confidence to commit. Often this reflects the absence of any official approach by the local authorities towards BIM, resulting in the lack of a framework with local integration.

There are support and training considerations that need to be addressed to ensure that there is confidence in the deployment. Although as a company we commit to provide these internally not all stake-holders are in the same position.

Local hardware procurement can prove difficult in some regions and entering countries with hardware can be prohibitive due to the additional expenses incurred with taxation and transportation.

For a successful implementation of BIM, all the above need to be understood and tackled. For some instances there is no resolution other than accept the issues and try to minimize their impact.

3.2. Our trumps

The experience and conclusions drawn from our BIM projects to date have resulted in a number of points that we can use to demonstrate the advantages of BIM. The major items are: Elimination of waste over the entire life-cycle; reduced re-working (through good BIM protocol documentation); improved predictability; detailed design evaluation (sustainability, life cycle carbon costing, etc.); post construction validation and information for building management by applying COBie framework. Specific to our experience and input we have found that the benefits with employing BIM on projects far supersede the added productivity from using new software, the largest gain we have managed to quantify is in the coordination of our work with others. Having established a regular cycle for exchanging information on projects with a weekly update (to the cloud) where clashes are evident and inspection of the development of a project is continuous, our focus can be on permanent productive improvement and coordination rather than amending, revising and issuing instructions for re-work to sub-consultants.

Beyond this one of the unexpected lessons we have learned is through the interest and commitment of individuals once the principles of BIM are grasped and the initial learning curve with software is achieved. There is an almost universal shift from concern to excitement and desire to learn more, we have found that in many instances motivation is boosted, providing an immeasurable benefit to the entire process and its development.

One of the latest developments in our BIM processes is the application of Cloud technology for BIM management and information sharing. This has proven a real added value factor for all participants at all levels even managing to reach the non-technical individuals through mobile BIM apps that open a "window" in what traditionally would have been a "blank wall".

4. Conclusions

The most important conclusion of our experience so far would have to be that the global transition to BIM in the construction industry is both inevitable and is rolling out at a faster pace than would ever be predicted. The understanding of what BIM is (and just as important what it is not) and acceptance of the integrated processes it entails are paramount and are now starting to develop a global reach.

Broadway Malyan has in many instances taken a leading role in implementing BIM in projects and has committed resources to aid other consultants in this transition. This is both in tune with the underlying principle of BIM that is sharing information and processes as it is beneficial to us given that the success of BIM relies on all stakeholders fully committing.

We see the growth and development of BIM as a major advance for our industry as a whole and support the initiative of facilitating this through an open discussion on the matter and believe that we have a valid input to this process.

BIM adoption: a demanding option

Mêda, P.; Sousa, H.
Portugal
Porto University School of Engineering

1. Introduction

This paper presents a first hand, practical overview on the process of adopting and deploying BIM solutions by a small Portuguese engineering practice and an established structural engineering company in São Paulo, Brazil. We believe that BIM adoption, at least in the domain of structural engineering, requires the development of detailed modeling rules, the customization of available software tools and, in some cases, the development of original applications. Although the advantages of BIM adoption are widely publicized, we have found that the initial obstacles that are met are significant. On the other hand, the opportunities that result from using BIM from the initial design stages are important and often unexpected. The aim of this paper is to review current arguments for BIM adoption and to share some of the solutions found for common problems, considering our shared work experience.

2. The Lure: Obvious advantages

Initial advantages are well publicized, both by academics and software vendors. Amongst these are the automation of drawing tasks and the development of a fully interoperable workflow. Although the potential of BIM tools to deliver these advantages is clear, they are yet to be fully achieved, both due to human, process and technological limitations. Obvious advantages are not obtainable by simply acquiring software licenses and hardware, but require a profound redesign of traditional work procedures. BIM researchers often refer to hype cycles when assessing future perspectives of recent technology [1, 2]. These representations, despite their significant shortcomings, warn early adopters of promising technologies about the lure of initial apparent advantages. Although hype cycles should not be read as templates for future productivity of BIM (thus, the "plateau of productivity" should not be taken as a given), some signs of its development are already clear. Early BIM adopters should, therefore, take into account goals that can realistically be achieved by current technology, expected obstacles and opportunities presented by this recent, still evolving approach to construction information management.

3. Obstacles and disappointments

Several obstacles to a seamless BIM adoption process can be identified. BIM is a recent technology that lacks well defined and well implemented standards. Most countries are yet to develop detailed BIM modeling rules or even general BIM roadmaps, which increases risk for early adopters. Existing professional AEC organizations rely on technology and processes that are largely incompatible with the requirements presented by BIM. They are required to develop documents that are identical to their traditional counterparts, which sets both technological but mainly process related challenges. There is a clear lack of well trained professionals [3] with a solid background of BIM fundamentals and proficient in the use of BIM tools. Existing training is sometimes found to focus on 3D modeling aspects, disregarding the importance of developing models with rich semantics. This is a two-fold problem for organizations: on one hand, it is difficult to find suitable staff, on the other, since existing professionals lack BIM skills, interoperability is hindered by the quality of models being exchanged. Even when working with professional partners who have already adopted BIM as main design process we have realized that each BIM implementation has a different scope and flavor resulting into interoperability issues. To overcome these interoperability issues a complete set of modeling standards should be defined within the design team prior to the actual modeling phase [4]. The establishment of such modeling rules requires traditional design processes to be reshaped and demands a deep knowledge of a BIM driven workflow, not always easily attainable in a small practice.

Extensive time and training must be considered for an effective BIM implementation where every existing CAD based design workflow needs to be assessed and eventually re-designed for a BIM environment. This is particularly challenging considering that clients often require design documents to resemble traditional CAD drawings. Furthermore the current status of interoperability between different software packages is still limited resulting in a major bottleneck to a seamless implementation of BIM as a central data hub. For instance, linking structural design software with a centralized BIM model using "out of the box" software tools is still a challenging task and the attained results are sometimes discouraging. The current national economic environment presents both a challenge, as new construction projects are scarce, and an opportunity since companies are now forced to look abroad for work alternatives and to comply with international standards.

4. Opportunities

Besides advantages that derive from automational effects [5] that increase productivity by reducing labor requirements, BIM offers a set of advantages related to the development of a semantically rich construction information model which can be shared among different applications and users. This, in turn, allows AEC professionals to efficiently develop custom solutions that cater to a wider variety of customer requirements. A closer level of interaction between design and manufacture is possible and is well supported by a BIM workflow allowing the design team to embrace tasks that were typically developed during, pre-construction, or construction phases. For instance a rebar-bending schedule can be obtained from the 3D design reinforcement model and directly linked with an automatic cut and bending station. In the case of construction design offices, as is the case of the organizations involved in the preparation of this paper, BIM favors the development of stable work partnerships. Fluent information transfer depends on the establishment of communication protocols and in the absence of well-defined modeling rules, organizations are required to develop and agree on these standards. This is especially evident in the case of international collaboration initiatives. The authors of this paper have collaborated in BIM projects in Brazil and the United Arab Emirates and the initial effort required to develop functional workflows in the first projects has improved efficiency in later common designs

5. Conclusions

BIM adoption is a demanding option. Currently, and as long as BIM project delivery is not a legal requirement, designers may regard the use of this technology as a choice, considering the opportunities and the threats it represents. It is, however, a demanding option, especially for established organizations and professionals. As is the case of all emerging technologies, the resistance to change is a major challenge [6]. Previous work practices will often appear to be more efficient, especially when facing demanding deadlines or budgets. We believe that BIM adoption requires administrations to understand BIM fundamentals in order to support an adequate process implementation. The establishment of a widely accepted BIM modeling rules would be very beneficial to the development of collaborative design between organizations from different countries. In the absence of these rules, organizations or groups of organizations should strive to develop BIM standards according to their requirements.

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BIM Technology	**Taking Building Information Modelling Mobile** Miskimmin, Iain United Kingdom COMIT/ Bentley
	BIM-based e-procurement and the PLAGE R&D project Costa, António Aguiar; Grilo, António Portugal; Portugal Instituto Superior Técnico, Technical University of Lisbon; Faculdade de Ciências e Tecnologia, New University of Lisbon
	Coding with IFC: some practical steps Regateiro, Francisco; Costa, António Aguiar Portugal Instituto Superior Técnico, Technical University of Lisbon
	Development of 3D interfaces for mobile BIM applications Martins, João Poças Portugal University of Porto

Taking Building Information Modelling Mobile

Miskimmin, Iain
United Kingdom
COMIT/ Bentley

1. Introduction

Alongside the US and Middle East the UK is now leading the global move towards the adoption of Building Information Modeling (BIM) technologies and associated new work practices,. Construction companies are keen to exploit improved information sharing to achieve cost savings and operational efficiency. But is the lack of mobile technology used in the field set to constrain innovation and prevent organizations realizing true "endto-end" value and benefit from the adoption of BIM technologies, competencies and techniques.

2. BIM Imperative

There is no doubt the UK Government's decision to demand suppliers involved in public sector projects to use Building Information Modeling (BIM) tools and techniques by 2016 has focused the attention of the construction industry. To date, this approach has only facilitated collaboration in the early phases of building design and construction. And while there is no doubt that early insight into potential problems of access or conflict are key to minimizing delay and costs, that improved information resource has huge – it could be argued, significantly more – potential on site.

Today, far too much time is lost as a result of workers lacking the required information to do the job. Whilst the problem is manageable if the site office is only minutes away, on major construction projects for roads or other infrastructure, this is rarely the case and workers have to travel miles to attain information or carry vast quantities of paper based information – from drawings and equipment schedules, to method statements. And there is no guarantee this information is up to date.

Given the pressure on pricing as a result of the UK Government's desire to cut costs by 20%, construction companies and building operators simply cannot afford to waste time with workers left idle due to lack of information. Nor can they risk mistakes due to inaccurate, incomplete or just incorrect information that leads to rebuilds and the cost of additional materials, getting rid of the old materials and the carbon overhead. The financial implications are huge.

3. Performance and Improvement

The essence of BIM is information sharing – not only 3D designs but also the related documents. These could include anything from the part reference numbers, through the maintenance scheduling to the social media conversation where decisions were made about how best to construct it.

With a consolidated information resource that includes drawings, specifications, commissioning requirements, method statements, health and safety assessments, environmental assessments and supply chain logistical information, a company can extend BIM from the original design through on site construction to on-site maintenance and repair. Add in key resources such as time sheets and employee training records to ensure they have the right skills and equipment expertise, and the technology also improves site management and project control.

By providing a worker with access at the point of activity to the information they require, relevant to their role and the task they are performing then their productivity and efficiency could improve dramatically. But it is important not to overwhelm an individual with too much information or information that is non-relevant to their role. Location based services and technologies can be used to identify each person, their location on site, and work package, making it a simple process to provide them with relevant information, and the ability to access more in depth information if needed.

4. Mobile Challenge

There are some obvious challenges associated with delivering mobile technology on a construction site – from the availability of connectivity to the durability of devices and health and safety concerns.

Many construction companies have banned the use of mobiles on site, because of the risks associated with distraction of the operative putting them in direct danger from powered equipment and other site based obstacles and hazards. One possible solution to this is though the adoption of Real Time Location Services (RTLS) technology that leverages Wi-Fi and other systems to alert the individual to the nearby presence of vehicles or equipment.

A new approach to the procurement and management of mobile IT hardware could also reap significant cost savings. Traditionally investment is made in ruggedized equipment that requires careful selection, testing and is often very costly to purchase and maintain. This approach requires that the new assets be given a long period of use (say 4 – 5 years) to derive the maximum value from the investment. During this time the equipment can fast become effectively obsolete given the rapid pace at which Mobile IT is evolving.

Recent new innovations in consumer targeted hardware (such as tablets such as the iPad) give the opportunity for a new perspective. Tablets are cheap and can be retrofitted with durable cases to provide ruggidisation. The significantly lower costs mean that these devices can be regarded much like a consumable item and replaced more cheaply once damaged beyond economic repair. Couple this with the fact that many companies now give their users these new devices after a period of use means that users value and look after their equipment more. In these examples companies have seen replacement levels actually fall from figures of around 20-30% per annum to around 3% - a significant saving.

One significant problem that continues to trouble organizations is that of site communications and their rapid deployment to construction sites. This is especially true given the volume of data now being transferred, between core 3D building information systems and software. With a lag between the time it takes to get comms on site – typically around 12 weeks – and the lead time available to the construction company, which is usually around 2 weeks, organizations must manage a mixture of satellite, 3G and microwave solutions to achieve necessary connectivity. The issues are manageable but require planning and awareness of connectivity restriction and the applications required at sites in order to minimize the impact on data transfer rates.

5. Conclusion

The UK Government's commitment to BIM makes good sense and the challenges and opportunities offered by its BIM strategy are going to drive significant changes in the way our industry works and collaborates with information on construction projects.

But the 20% cost savings identified will not be realized simply by improving information sharing between designers and construction companies during the planning and design phases of the project lifecycle. The big benefits will be achieved on site during construction and through more effective operations and maintenance and that demands real-time, mobile access to in-depth and tailored asset information.

With the barriers to mobile adoption diminishing fast and construction companies working hard to embrace collaborative working and BIM to improve information sharing across the supply chain, the goal of end-to-end asset visibility is at last becoming achievable. Those organizations that fail to respond to the mobile imperative will not only get left behind but will also struggle to achieve the effective, efficient operations required to compete in a lower price point marketplace.

To answer this challenge the industry has asked COMIT (Construction Opportunities for Mobile IT) an organization with over 10 years' experience in deploying mobile technology onto construction sites to run a group focused on helping the industry deliver information mobility.

Over the next 3 years, the BIM for Mobility working group will be looking at all aspects of mobile computing in a construction environment. The tasks identified range from the enablers (connectivity and hardware), through auto ids (RFID, bar codes and biometrics) to the bigger cultural issues (user acceptance, health and safety and training). This will culminate in a "cook book" style report allowing construction companies to define their ingredients (type of site, type of project, duration, environment, etc.) and be given a recipe for successful deployment of mobile technology.

The working group is co-chaired by Matt Blackwell from Costain and Iain Miskimmin from Bentley.

6. Acknowledgments

COMIT – BIM for Mobility – www.comitproject.org.uk/

BIM-based e-procurement and the PLAGE R&D project

Costa, António Aguiar[1]; Grilo, António[2]
Portugal
[1]Instituto Superior Técnico, Technical University of Lisbon
[2]Faculdade de Ciência e Tecnologia, New University of Lisbon

1. Introduction

E-business platforms, which may take different forms [5,7], play an important role as communication and business process management instruments, emerging as an effective support to collaboration, information management, and sharing [2,10]. The extranets supported by these electronic platforms capture the supply chain communication practices and provide controlled communication, becoming progressively evident for the industry the relevance of information sharing instruments [1]. Considering these emerging issues, an innovative approach to e-procurement in construction, which is based in Building Information Modeling (BIM) paradigm, is proposed. The result is an integrated instrument connected to a rich knowledge base capable of advanced operations and able to strengthen transaction relationships and collaboration throughout the supply chain.

2. Materials and method

The present study was developed as an action research [8] conducted within a business environment and a team of several elements, presupposing strong commitment between research and collaboration with team members [4]. This participative and collaborative process was based on several research cycles, which converge on better understanding of the problems and phenomena throughout a learning process based on continuous refinement of methods, data and interpretation [6]. The research cycles focused on three major phases:

- exploratory study and proposition of a BIM-based e-procurement framework;
- development of a prototype of the solution proposed;
- simulation and test of the prototype developed using a pilot case study, an experiment with a fixed approach and a controllable environment.

3. Results and Discussion

3.1. Use cases and front-end development

The first step toward prototype development was to model traditional workflow for the construction e-procurement lifecycle, which included the identification of the various players and respective value-added activities, information flows mapping, determination of major deliverables and decision points. Business Process Modeling Notation (BPMN) was used to model all traditional processes inherent to construction lifecycle phases. Afterwards, BPMN diagrams were analyzed in detail and several modifications were introduced into the workflow to optimize information flows and enhance collaborative work recurring to existing technologies such as BIM. Existing e procurement platforms were the starting point for developments proposed.

The resulting BPMN diagrams supported the development of a functional matrix in which the functionalities of the platform for each phase and each type of user were identified that considered information requirements identified previously. Considering the functional matrix and the BPMN diagrams, the use cases were defined and, in accordance to use cases specifications, front-ends were constructed.

3.2. Platform architecture

To support the BIM-base procurement framework proposed, the electronic platform has been developed integrating and combining three different platforms. Microsoft SharePoint 2007 was used as the business collaboration platform system and as the front-end and to implement a set of workflow and rule-based procedures for the e-procurement. The EDM Model Server from Jotne EPM Technology was used to implement BIM-based features such as storing and manipulating IFC models. The IFC Engine Viewer provided by TNO was used as an IFC 3D viewer. Vortal eGOV is an e-procurement platform for the AEC sector. The disparate platforms work seamlessly in an integrated way through Web-services connections.

To structure the development of the platform, the service-oriented approach was organized into four layers:

• presentation layer, providing the application user interface and involving forms for smart client interaction and ASP.NET technologies for browser-based interaction;

• application services layer, implementing the business functionality of the application, composed of a number of components implemented using one or more .NET programming languages;

• Business services layer, supporting business services connected with external services using SOAP;

• and data layer, providing access to external systems such as databases.

3.3. BIM-based interface

The BIM-based interface was created according to the proposed solutions and it supports two major advanced features:

• view and manipulate IFC models, and access to all the information contained in the models (Figure 1);

• manage tasks and other information related to each BIM element, from which it is possible to initiate the e-procurement process using the connection implemented with Vortal e-procurement platform (Figure 2).

Figure 1 – BIM viewer (IFC-based)

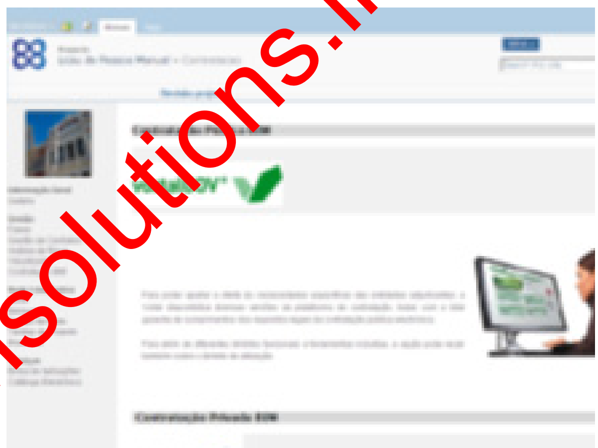

Figure 2 – E-procurement

The BIM-based platform developed was tested in a pilot case, which focused on a school-remodeling project.

Throughout the test several issues were addressed regarding implementation of innovative BIM-based e-procurement solution.

4. Conclusions

The BIM-based e-procurement interface have shown to be useful, though the success of its implementation requires a deep understanding about how to create the models and how to classify the information included in the models. During pilot case study some problems were identified, particularly regarding the interoperability models: when transformed into IFC the models lost some information included on the original proprietary format. Therefore, the solutions proposed are dependent on the dissemination of standardized taxonomies.

A BIM-based e-procurement solution may potentiate more strategic approaches to e-procurement, as it improves information management potential, stimulates collaboration and maximizes supply chain management. In traditional e-procurement platforms, collaboration arises primarily from buying requirements for procurement through the specification development process by using real-time communication and exchange of information [3,9]. Though, a BIM-based e-procurement vision may extend these capabilities to design and development of products, manufacturing processes, logistics and distribution strategies.

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Coding with IFC: some practical steps

Regateiro, Francisco; Costa, António Aguiar
Portugal
Instituto Superior Técnico, Dept. of Civil Eng., Architecture and Georesources

1. Introduction

buildingSMART International (bSI) is one of the most active organizations working for the development and use of open standards for Building Information Modelling (BIM) [1]. bSI aims to improve data sharing and communication during whole lifecycle of built environment, encompassing decision making, design, production, facilities management, engineering maintenance, and demolition. Industry Foundation Classes (IFC) corresponds to a neutral and open file format specification, registered as ISO 16739, developed and maintained by bSI as the specification of its preconized model to describe the AEC/FM data [2]. Coding with IFC using a programing language, such as Java [3] or C# [4], besides being the most flexible way of working with IFC, is an excellent way of gaining insight about IFC. Following this perspective, we make here an introductory incursion into the territory of IFC. We articulate with IFC terminology and we code with programming libraries that implement IFC.

In section 2, we introduce some IFC concepts. Section 3 contains three coding examples: (1) reading an IFC file, (2) iterating doors and windows by filling relationship, and (3) iterating doors and windows by floor. Section 4 ends with the concluding remarks.

2. Industry Foundation Classes

The Industry Foundation Classes (IFC) includes the formal definition of modelling entities (from now on designated only as entities), which correspond to concepts that are present in the AEC/FM universe of discourse. It also includes assumptions about the use of entities for particular scenarios. Entities correspond to hierarchically organized types of information characterized by attributes and constraints. The top-most entity of the hierarchy is the IfcRoot, which has four attributes: GlobalId, OwnerHistory, Name, and Description. Therefore, all other entities inherit these attributes from it.

All entities are grouped in 38 schemas, which are themselves organized in four conceptual layers: (1) the core layer, which encloses four core schemas; (2) the interoperability layer, which encloses five shared schemas; (3) the domain layer, which encloses eight domain schemas; and (4) the resource layer, which encloses 13 resource schemas. The complete presentation of the IFC specification goes beyond the scope of this text. We recommend the examination of the official documentation in the bSI website for that purpose.

In the context of the IFC specification, product means anything physical or conceptual that has a distinct existence and occurs in space. This concept is represented by the entity IfcProduct, which belongs to the kernel schema, one of the four core schemas. IfcProduct is an abstract entity, which has other inheriting entities as subtypes: (1) IfcElement (physical product), (2) IfcSpatialElement (spatial product), and (3) other entities that correspond to non-physical products.

The product extension schema, another of the four core schemas, includes not only entities that correspond to products, such as IfcBuilding, IfcBuildingElement, IfcBuildingStorey, IfcElement, IfcOpeningElement, IfcSite, IfcSpace, and IfcSpatialElement, but also entities that correspond to relationships, such as IfcRelContainedInSpatialStructure, IfcRelFillsElement, IfcRelDecomposes, IfcRelReferencedInSpatialStructure, IfcRelVoidsElement. The entity IfcOpeningElement corresponds to an opening, i.e., a void within an element (the type of the element may be constrained). There are connectivity assumptions regarding this entity. An instance of IfcOpeningElement has to be related to an instance of IfcElement (e.g., wall, slab, beam, or column) through an instance of IfcRelVoidsElement. Additionally, an instance of IfcOpeningElement may be related to an instance of IfcElement, like a door or a window, through an instance of IfcRelFillsElement, i.e., a filling relationship.

Any entity that is a subtype of IfcElement may participate in two different containment relationships. The first (and in most implementation scenarios mandatory) relationship is the (hierarchical) spatial containment; the second (optional) relationship is the aggregation within an element assembly (we will not cover aggregation in the examples below).

Spatial containment (IfcRelContainedInSpatialStructure) corresponds to the relationship of physical elements, such as building elements, distribution elements, or furnishing elements, as being contained within a spatial structure element. This relationship allows that an IfcSpatialElement, as a relating structure, be related to one or more Ifcproduct instances, as related elements. Subtypes of IfcSpatialElement are valid spatial containers. This is the case of IfcBuildingStorey.

We may agree, by the descriptions in the previous paragraphs, that IFC is an intricate territory, which then we prefer to explore gradually. Moreover, since there are available free application programming interfaces (APIs), we want to call the attention for the possibility of using the programming approach as a way to apprehend and experiment with IFC. Typically, there is a correspondence between the names of IFC entities and the names of corresponding programming classes. For instance, the IFC entity for storey will probably (depending on the API) be implemented as a programming class with the (same) name IfcBuildingStorey; as well as the entity for the containment relationship, which will probably be provided as a class with the (same) name IfcRelContainedInSpatialStructure. IFC JAVA TOOLBOX, IFCJT [5], and xBIM (eXtensible Building Information Modelling) Toolkit, xBIMT [6], are two available IFC API. We chose these API for this work because they are recent, provide clear online information, and support distinct programming languages (Java and C#). Obviously, in a constantly improving panorama of IFC programming tools, it is wise to check for updates about APIs in the bSI website.

In the scope of this work, we decided to put hands on IFC starting from the concepts of doors and windows. Therefore, searching in the official documentation, we were able to find the entities IfcDoor and IfcWindow inside the shared building elements schema, one of the five shared schemas of the interoperability layer. These two entities are (direct) subtypes of IfcBuildingElement, which is a (direct) subtype entity of IfcElement. IfcDoor and IfcWindow contain two quantitative attributes that correspond to width and height physical properties, OverallWidth and OverallHeight, respectively. Reading the documentation, we discover that the two entities have similar connectivity assumptions regarding element filling and spatial containment. A door or a window may fill an opening in another element, such as a wall. Additionally, a door or a window may be contained in a storey (desirably), or, alternatively, in a building or in a site; and only a door may, also alternatively, be contained in a space. We are next going to report the result of experimenting with this IFC knowledge through coding.

3. CODING EXAMPLES

We present three coding examples. The first shows how to load the data from an IFC file into a program variable. The second shows how to iterate through doors and windows using the element filling relationship. The third shows how to iterate through doors and windows using the spatial containment relationship. These examples lack some basic general code parts that will be necessary to compose a working program.

3.1. Reading an ifc file

Both API, IFCJT and xBIMT, provide one class that can be used to load, access and save the contents of IFC files. It is named IfcModel in IFCJT, and IModel in xBIMT. We show how to use these classes to load an IFC file into a variable named model, in Figure 2 and Figure 3.

```
String ifcFileName = "FileName.ifc";
IfcModel model = new IfcModel();
File input = new File(ifcFileName);

model.readStepFile(input);
```

Figure 2 – Reading an IFC file (in Java)

```
string ifcFileName = "FileName.ifc";
IModel model = new Xbim.XbimExtensions.XbimMemoryModel();
IfcInputStream input = new IfcInputStream(new FileStream(ifcFileName,
  FileMode.Open, FileAccess.Read));
input.Load(model);
```

Figure 3 – Reading an IFC file (in C#)

3.2. Iterating doors and windows by filling relationship

Both API implement a method to obtain the existing instances of a given entity. It is named getCollection in IFCJT, and InstancesOfType in xBIMT. In the code of Figure 4 and Figure 5, we iterate through all element filling relationships (IfcRelFillsElement) after using this method. Then, we use the methods getRelatedBuildingElement and getRelatingOpeningElement in IFCJT (RelatedBuildingElement and RelatingOpeningElement fields in xBIMT) to obtain the filler and the opening, respectively, from each relationship. Finally, when the filler is a door or a window, we write to the output some attribute values of the filler and opening entities.

```
Collection<IfcRelFillsElement> relations = model.getCollection(IfcRelFillsElement.class);
for(IfcRelFillsElement rel : relations)
{
  IfcElement filler = rel.getRelatedBuildingElement();
  IfcOpeningElement opening = rel.getRelatingOpeningElement();
  if (filler.getClass() == IfcDoor.class)
  {
    System.out.format("%s // %s // %s -> FILLING -> %s // %s\n",
      filler.toString(), filler.getGlobalId(), ((IfcDoor)filler).getOverallWidth(),
      opening.toString(), opening.getGlobalId());
  }
  else
  if (filler.getClass() == IfcWindow.class)
  {
    System.out.format("%s // %s // %s -> FILLING -> %s // %s\n",
      filler.toString(), filler.getGlobalId(), ((IfcWindow)filler).getOverallHeight(),
      opening.toString(), opening.getGlobalId());
  }
}
```

Figure 4 – Iterating doors and windows by filling relationship (in Java)

```
IEnumerable<IfcRelFillsElement> relations = model.InstancesOfType<IfcRelFillsElement>();
foreach (IfcRelFillsElement rel in relations)
{
  IfcElement filler = rel.RelatedBuildingElement;
  IfcOpeningElement opening = rel.RelatingOpeningElement;
  if (filler.GetType() == typeof(IfcDoor))
  {
    Console.WriteLine(string.Format("{0} // {1} // {2} -> FILLING -> {3} // {4}",
      filler.ToString(), filler.GlobalId, ((IfcDoor)filler).OverallWidth,
      opening.ToString(), opening.GlobalId));
  }
  else
    if (filler.GetType() == typeof(IfcWindow))
    {
      Console.WriteLine(string.Format("{0} // {1} // {2} -> FILLING -> {3} // {4}",
        filler.ToString(), filler.GlobalId, ((IfcWindow)filler).OverallHeight,
        opening.ToString(), opening.GlobalId));
    }
}
```

3.3. Iterating doors and windows by floor

Using getCollection in IFCJT and InstancesOfType in xBIMT, as shown in Figure 6 and Figure 7, respectively, we are able to get all stories in a model, i.e. all instances of IfcBuildingStorey. Afterwards, we use the method getContainsElements_Inverse in IFCJT (ContainsElements field in xBIMT) to get all containment relationships (IfcRelContainedInSpatialStructure) from each storey; and the method getRelatedElements in IFCJT (RelatedElements field in xBIMT) to get all contained elements from each relationship. Finally, we write to the output some attribute values of each contained element that is either a door or a window.


```
Collection<IfcBuildingStorey> stories = model.getCollection(IfcBuildingStorey.class);
for(IfcBuildingStorey storey : stories)
{
  System.out.println(storey.getName());
  for (IfcRelContainedInSpatialStructure rel : storey.getContainsElements_Inverse())
  {
    for (IfcProduct product : rel.getRelatedElements())
    {
      if (product.getClass() == IfcDoor.class)
      {
        IfcDoor ifcDoor = (IfcDoor)product;
        System.out.println(ifcDoor.toString() + " // " + ifcDoor.getName() +
          " // " + ifcDoor.getGlobalId() + " // " + ifcDoor.getOverallWidth());
      }
      else
        if (product.getClass() == IfcWindow.class)
        {
          IfcWindow ifcWindow = (IfcWindow)product;
          System.out.println(ifcWindow.toString() + " // " + ifcWindow.getName() +
            " // " + ifcWindow.getGlobalId() + " // " + ifcWindow.getOverallHeight());
        }
    }
  }
}
```

Figure 6 – Iterating doors and windows by floor (in Java)

```
IEnumerable<IfcBuildingStorey> stories = model.InstancesOfType<IfcBuildingStorey>();
foreach (IfcBuildingStorey storey in stories)
{
 Console.WriteLine(storey.Name);
 foreach (IfcRelContainedInSpatialStructure rel in storey.ContainsElements)
 {
  foreach (IfcProduct product in rel.RelatedElements)
  {
   if (product.GetType() == typeof(IfcDoor))
   {
    IfcDoor ifcDoor = (IfcDoor)product;
    Console.WriteLine(ifcDoor.ToString() + " // " + ifcDoor.Name +
     " // " + ifcDoor.GlobalId + " // " + ifcDoor.OverallWidth);
   }
   else
    if (product.GetType() == typeof(IfcWindow))
    {
     IfcWindow ifcWindow = (IfcWindow)product;
      Console.WriteLine(ifcWindow.ToString() + " // " + ifcWindow.Name +
      " // " + ifcWindow.GlobalId + " // " + ifcWindow.OverallHeight);
    }
  }
 }
}
```

Figure 7 – Iterating doors and windows by floor (in C#)

4. Conclusions

We presented an introduction to IFC concepts and to programming with IFC. We used two recent IFC toolboxes, one supporting Java and the other C# programming language. We developed code examples that may process any IFC model. Even with simple purposes, these examples give useful basic information about programming with IFC entities. We conclude that it is easy to apprehend the concepts and experiment with IFC entities through programing with the chosen API and their IFC implementing classes.

In the future, we intend to develop programs that will manipulate more IFC entities. Moreover, this future development will cover not only inspection of existing models, but also the modification and creation of new models.

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[6]xBIM Toolkit. [Online]. Available: http://www.openbim.org. [Accessed: 01-May-2013].and creation of new models.

Development of 3D interfaces for mobile BIM applications

Martins, João Poças
Portugal
University of Porto

1. Abstract

Although interoperability is a keyword that has been associated with BIM since its early days [1], achieving full interoperability is far from being achieved [2]. Significant obstacles to this goal include limitations of current technology and the lack of advanced modeling skills in different stages of the construction process. Mobile devices can play an important role in allowing BIM to be used by AEC professionals, in particular beyond the design stage. Besides the obvious advantage of portability, current mobile devices allow a variety of forms of user input to occur, including touchscreens, accelerometers and gyroscopes. They are location-aware and are suitable for the development of 3D interfaces that use information generated by general BIM applications.

A mobile BIM application with a 3D interface has been developed and is briefly presented in this article.

2. Interoperability issues: Beyond exchange formats

Interoperability in the AEC industry is often addressed in the context of the development of suitable data formats that should allow information to be exchanged among software applications. Although Building Information Modeling is a relatively young technology, significant steps have been taken in addressing software interoperability issues through the use of both open and propriety exchange formats in the last two decades. AEC specialists play a critical role in the continuous improvement and empirical validation of these formats.

Besides software interoperability, human and institutional interoperability should be assessed when considering the efficiency of information management in the AEC industry [3]. These aspects are particularly important considering the lack of personnel with BIM skills, which is an obstacle to the adoption of this technology [4]. BIM-related courses are a part of a growing number of higher education AEC programs [5] but widespread BIM adoption, in particular beyond the design stage, requires the development of software and hardware solutions that are suitable for the skill level of existing professionals, as well as adequate for the environment where they will be used.

3. Mobile bim

Mobile devices are increasingly used in professional construction environments. Several of the most popular commercial BIM tools currently provide compatible mobile applications which allow users to access a subset of the information that composes the original BIM model. Effective use of these tools on-site requires them to be flexible and customizable.

Although the flexibility of available mobile BIM applications is quite limited, their desktop counterparts are programmable and import and export information in a growing variety of popular exchange formats. This enables the use of a wide range of software tools that complement modeling applications and extend their functionality.

In recent years the development of mobile devices and infrastructure enable Augmented Reality (AR) applications [6], which justifies the increased attention of the AEC community [7]. AR applications provide an intuitive interface between the physical built environment and the virtual nD model, which enables multiple parties to experience the design as digital models outside the design office environment [8].

The development of custom-built, BIM-based AR applications requires the simultaneous availability of several compatible software and hardware components. Besides the BIM tools that are used to generate models, 3D engines can be used to display graphics. Non-graphical information can be exported using standard IFC or ODBC (Open Database Connectivity), besides other alternatives. This information must be combined and made accessible on a mobile device which must accept user input from a gyroscope.

Location-awareness may be provided by GPS and compass readings. All of these requirements are supported by current mobile devices.

4. Developed mobile application: brief description

A mobile application has been developed in a partnership between the University and a local structural engineering office that currently works exclusively in overseas projects using BIM. Mobile BIM applications allow the information from the structural model to be shared and used in construction activities downstream from the design phase with only a modest increase in work hours when compared to the usual workflow for detailed structural design modeling.

A popular 3D engine was used to support graphics on the mobile device (Figure 1) and an embedded database management system was used for non-graphical data. Since these two data export operations occur separately, it is critical to guarantee that individual BIM objects are correctly identified in both versions. Different alternative software components and data formats were assessed in order to ensure compatibility and interoperability. It was found that the quality of information transfer varies significantly and depends on the BIM application used to develop the model.

Some applications do not preserve BIM objects' Global Unique Identifiers (GUID) along with geometrical information when exporting to 3D file formats. In other cases, visual information such as materials and textures was not transferred correctly. A compatibility chart was developed based on the empirical assessment that was performed.

The 3D interface can be used to navigate the model using input from the mobile device's gyroscope (Figure 2) or the touchscreen. It is also possible to use the device's camera to register events on-site.

5. Case study

A simple case study has been developed in order to support development and to illustrate the use of the application. A single-family house has been modeled in order to develop a 3D interface to be used for on-site building inspection tasks (Figures 1 and 2). Mobile devices can be used to browse the model and add information (unstructured text, numerical data and images from the device's camera). The device's motion sensors are used to browse the model. Although mobile devices are location-aware, in this case the GPS is not used because the application is meant to be used indoors. The compass is also not used because it was found to be unreliable, probably due to magnetic interference inside the building.

Two alternative commercial BIM applications were tested to develop the model and its geometry was exported in FBX and OBJ file formats. Although each format has specific advantages, both solutions were found to be feasible for this specific case study. Two different 3D modeling applications were tested to edit the files exported by the BIM applications before these were imported into the 3D engine, but this is not a required operation. The application itself was developed mostly in C#. In this case, only geometrical information was exported from the BIM model but, since each element's GUID was preserved, the information can be linked to an IFC model.

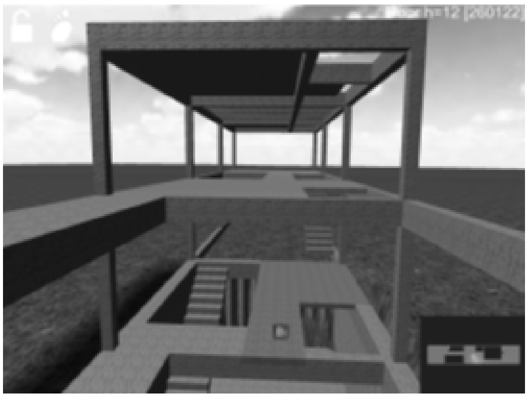

Figure 1 – Developed Mobile Application Reinforced concrete elements.

Figure 2 – On-site use of application (example). Input from device's gyroscope.

6. Conclusions

Mobile devices can play an important role in allowing BIM to be used by AEC professionals, in particular beyond the design stage. They support 3D graphics and non-graphical information exported by popular desktop BIM applications as well as different forms of user input.

A mobile augmented reality application has been developed with add-ons for design review and on-site building inspection. The application allows BIM models developed in-office to be shared, browsed and non-graphical information to be edited on mobile devices.

Although modern BIM applications export data in a wide range of different data formats, systematic empirical assessment is required to ensure a desired level of interoperability.

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Education	**Collaborative Intelligence in the educational context of BIM** Marques, Sandra France École Nationale Supérieure d'Architecture de Toulouse/ Laboratoire de Recherche en Architecture (LRA)
	Crossrail and Bentley Information Management Academy Miskimmin, Iain United Kingdom Bentley / Crossrail
	Educational activities for the teaching-learning of BIM Barison, Maria Bernardete; Santos, Eduardo Toledo Brazil University of São Paulo

Collaborative Intelligence in the Educational Context of BIM

Marques, Sandra
France
École Nationale Supérieure d'Architecture (ENSA) de Toulouse/ Laboratoire de Recherche en Architecture (LRA)

1. Introduction

In France several efforts have been undertaken to encourage the adoption and implementation of Building Information Modeling (BIM). Some of these initiatives have proved successful, but in general, the national framework has not yet reached the desired coverage, especially with regard to the academic realm. Deeply rooted in various areas of research and development in computational design over the past 30 years [1], BIM is often misconceived as being a new kind of digital tool to represent a 3D model by replicating CAD processes more effectively. The term BIM means different things to different people, and sometimes it causes confusion rather than providing clarification. In fact, it is difficult to present a satisfactory definition of BIM and we don't propose to offer yet another definition here. In our opinion, the most appropriate way to deal with the full scope of BIM is to understand it as socio-technical system taking in account the integration of man-made technology and the social and institutional consequences of its implementation in society.

The main objective of this extended abstract is to present our participation as teacher and researcher in two pedagogical experiments at the School of Architecture of Toulouse (ENSA) in France: the first one was carried out during the second semester of 2010 focusing on the inter-disciplinary collaborative use of BIM (between students of architecture and students of engineering at Paul Sabatier University); the second, carried out during the second semester of 2011 focusing on the intra-disciplinary collaborative use BIM (between students of architecture).

2. Materials and method

Despite their differences concerning approaches of design modeling and design collaboration, both pedagogical settings (called "Maquettes Numériques et Nouvelles Pratiques de Collaboration") are based on the epistemological framework in which the cognitive, procedural and relational dynamics of teamwork are as important as technical issues. Both take in account the multi-faceted concept of information, its digital manipulation and its collaborative sharing (in asynchronous and synchronous mode). They are offered to students enrolled in the third year at the School of Architecture of Toulouse (duration: 13 weeks/ 3 hours per week). In Table 1 we present a summary of the implementation methodology and materials used.

Table 1 – BIM pedagogical experiments at ENSA of Toulouse: some characteristics.

Session 2010	Session 2011
Collaboration settings: Inter-disciplinary collaborative work between architecture and engineering students. One student of architecture and three engineering students (from Paul Sabatier University) compose each team (total of 6 teams). Activities are mostly in distributed and asynchronous mode (only two sessions take place in face to face). Communication media: mail, skype, IFC viewers, online project management platform.	**Collaboration settings:** Intra-disciplinary collaborative work between students of architecture (from ENSA of Toulouse) working by binomials (total of 6 teams). Modeling activities are mostly in synchronous mode using the interface of Teamwork – BIM Server technology of ArchiCAD. Communication media also include, sketches, IFC viewers.
Objectives/program: To model existing buildings of Toulouse using BIM technologies and processes (mostly are schools constructed between 1960-1990). To use the model to calculate surfaces and environmental impacts of the building and propose new design hypotheses in order to achieve the requirements of the label BBC ("Bâtiment Basse Consommation"): maximum energy consumption at 50 kWh of primary energy/m2/year.	**Objectives/program:** To experience a process of collaborative work involving all students of architecture in the production of the BIM model of a public facility. The building chosen by students is the School of Architecture de Toulouse (originally designed by the architect Georges Candilis in the late 60's). Then each team should design an extension to building (maximum 600 m2) according to the program proposed by teachers.
Processes/Tools: The Urbanism Department of Toulouse provides all documents about the existing buildings (PDF or DWG documents). At the first step, architecture students produce the BIM models using ArchiCAD or Revit (according to their level of proficiency in the software). They use the BIM models to area calculations and environmental impacts. These models are placed on an online project management platform (in both native and IFC formats). Models are exploited by engineering students that use "Climawin" (thermal calculation software developed by the French editor BBS Slama which supports the IFC format).	**Processes/Tools:** The Urbanism Department of Toulouse provides documents about the existing building (PDF or DWG documents). The BIM Model is created using the BIM Server technology of ArchiCAD. At the first step of modeling, the building is divided into zones that are assigned to each pair of students. All together, students discuss and analyze spatial composition, structure and materials and establish a working methodology to optimize the modeling process of the existing building (creation and sharing of components/3D parametric objects in real time). During the second step (design of the extension), each binomial works separately and proposes a design solution.
Assessments: During the final presentation teams make a comparative analysis between the different models proposed (before and after changes) and answer a questionnaire about the methodology and tools used during the experiment.	**Assessments:** Project evaluation cover the compliance of extension program and the requirements of the national thermal regulation RT2012. Students are asked to answer a questionnaire about the methodology and tools used during the experiment

3. Results and discussion

In general, there is not so much hesitation why and what for we need BIM within the Architectural, Engineering and Construction (AEC) Industry. However, universities (and in our specific case, the French Schools of Architecture) are lagging behind introducing graduates skilled in collaborative design practices and BIM. Some surveys on the adoption of BIM have found a gap between promises and reality. As argued by Neff [2] "even though BIM usage has doubled since 2007, work practices that support increased collaboration and knowledge sharing across organizational and disciplinary boundaries have been slow to emerge". Some problems related to object-oriented building modeling and BIM in education are also discussed in some papers [3, 4, 5, 6].

In fact, any major change process is likely to encounter resistance. The two BIM pedagogical experiments presented in this extended abstract are not exempt from this fact. Despite the growing interest of students, they are categorized as optional courses or "modules d'ouverture" in their curriculum and they still remain disconnected from the activities carried on the design studios ("les ateliers de projet"). In fact, most of design teaching staff don't ask for BIM in their architectural studios and sometimes even demote it.

Two surveys were sent to the design teaching staff (36 teachers) before the implementation of these two pedagogical experiments. Most of them (70%) expressed their opinions about the subject. The universe inquired in first survey was rather focused on advantages and constraints of using BIM technology and methods. The second survey was rather focuses on how can BIM be used to improve collaboration. The answers of the two surveys (questionnaires) and preliminary analyses of the BIM implementation at the School of Architecture of Toulouse show some difficulties: (1) Reluctance to change teaching/learning habits established over many years; (2) The difficult to bridge the traditional silos of architecture and engineering schools; (3) Questions about how to fit new topics into a crowded curriculum; (4) The necessity of academics to constantly keep abreast of the rapid pace in which technologies supporting BIM evolve.

4. Final remarks

Despite some criticism, it is observed that the support of the central government towards BIM in some countries can be regarded as the driving force towards a higher and coherent implementation and utilization of BIM. We could argue that this support can also provide an active environment of coordinated interfaces between research and education sectors, which are the two fundamentals pillars of BIM development and implementation. Of course, the effort of government alone may be not enough, and a strong involvement of private sector it is necessary to create new business processes, partnerships and collaborations which includes the software developers, research and development organizations, construction companies as well as educations institutes.

In France, the actual scenario of BIM implementation is more likely driven by the market conditions and private sector (BIM practices are not mandated in France). Actually, a study group supported by the non-profit association Mediaconstruct [7] – the Francophone Chapter of buildingSMART International and the referent of BIM in France - is discussing about the necessary changes to the "MOP" law or "Loi de la Maîtrise d'Ouvrage Publique". The "MOP" law establishes the legal basis of the public sector of the construction in France, including among others, the mission of the architect for the public procurement. The School of Architecture of Toulouse (ENSA) is taking part on these discussions.

These observations contribute to encourage further investigations to be followed up in future researches and provide alternative design learning experiences and curricula for those who want to build scaffolds to support designing in the context of what we call "collaborative intelligence". Our next effort will be to try to integrate principles of collaboration and BIM technologies into existing classes (design studios) throughout the curriculum of the ENSA of Toulouse in order to reduce the need to develop completely new optional courses.

5. Acknowledgments

We wish to thanks to all students who took part in these two pedagogical experiments.

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Crossrail and Bentley Information Management Academy

Miskimmin, Iain
United Kingdom
Bentley / Crossrail

1. Biggest barrier to BIM? Culture

I believe, and I think you'll agree that the biggest barrier to BIM is Culture. Construction as an industry has existed for thousands of years and little has changed in the way it's carried out apart from the technology that supports it. BIM is not about changing technologies, it's about changing the way we work, making us understand that through the smarter handling of information we can make owning and operating an asset easier, cheaper and safer.

To change the way we have always done things means that we must educate every tier of the supply chain and sell them the benefits of working smarter together through BIM.

Not so difficult when you have a single building to construct, many of us can handle "lonely BIM" but when you have 84 different contracts to be federated together into 1 asset that spans over 118kms in length, including 9 new stations, 42kms of bored tunnel and 41 new connections threading through one of the busiest underground networks of existing rail, utilities and structures you need to make sure that everyone can deliver the "Big BIM" that is required.

So how can you share your aims, processes, people, technology and experience with all those different contracts?

2. Crossrail – Bentley Information Management Academy

In November 2012 the academy was launched:

"The Academy will support the Government Construction Strategy by increasing the use of BIM in the construction industry and creating a lasting legacy of best practice in innovation" Andrew Wolstenholme (Crossrail Chief Executive)

"Beyond technology, what's most exciting for us about the Academy's potential contribution is what we can all learn from 'working smarter together' with the Crossrail construction supply chain." Greg Bentley (Bentley Chief Executive Officer)

The focus of the academy is on enhancing the knowledge of the supply chain, driving best practice and encouraging innovation and collaboration. To achieve that, the initial "on-boarding" session at the academy makes the contractors aware of the support mechanisms (technological and physical) put in place to help them deliver not only their contractual obligations but also encourage them to innovate and share their knowledge.

3. Onboarding

The On-Boarding sessions are normally project based, bringing together a team of asset, project, document and CAD managers along with the lead engineers and the contractors corporate BIM coordinator.

For the instructors the day starts with a bacon sandwich, for the students it starts with a simple question; "what does BIM mean to them"?

The answers are very revealing and reflect that BIM means different things to different people. The designer and the constructor have differing viewpoints and so does Crossrail!

The instructors at these sessions are all Crossrail staff who have been chosen for being experts in their subjects and excellent at getting their message across. The morning is split into 5 sessions:

1. The Crossrail Overview;
2. Document Control;
3. CAD Management;
4. Asset Management;
5. The BIM in Delivery Working Group.

Each of these sessions introduces the processes, people and the technology that Crossrail have put in place to help them deliver BIM Level 2.

Most of the attendees have used a document or cad management system before, but not one that links all the documents, cad and assets together in a smooth workflow.

To make things culturally acceptable we must make them simple and easy to use.

The BIM in Delivery Working Group is about driving innovation in the construction industry, initially through the Crossrail project but the aim is to raise the bar throughout. This is done through understanding the needs and business values before carrying out proof of concept trails.

The academy is an ideal location for this, as it is a complete replica of the Crossrail system. All the software, processes and data structures are mirrored there, allowing a laboratory approach by Contractors and Crossrail alike.

After the presentations the academy is open for the attendees to talk to the SME's and to try the software/ technology that have been shown, including digital pens, tablet computers and data matrix code examples.

We are currently starting to deliver more detailed briefings in 4D and Asset tagging.

4. Beyond crossrail

The academy format has been recognised as great example by the owner/operators around the UK and Europe as a way to deliver the requirements to their contractors and assist them in delivering smarter assets.

It has also been recognised that in the academy we have an excellent example of a light rail, tunnelling and building BIM. This will be expanded through something called the #BIGBIMWORLD, that will help demonstrate how we need to interface and connect Infrastructure (road and rail) with power stations, hospitals, docks, airports and utilities to create a big BIM world rather than the lonely BIM we see today.

To do this, three elements will be brought together. We are engaging first year engineering students who play The SIMS or MineCraft games. Why? Because they are already ahead in their use of 3D worlds with libraries of objects, which they manipulate and run as assets! Couple this with mentoring from the contractors coming through the academy and a Bentley software expert, over the summer we intend to create something pretty special!

The academy is also being used to bring together the owner/ operator's asset definition dictionaries to allow a free exchange of knowledge around the granularity of information that should be captured, handed over and used to maintain a world class infrastructure asset.

Educational Activities for the Teaching-Learning of BIM

Barison, Maria Bernardete; Santos, Eduardo Toledo
Brazil
University of São Paulo

1. Introduction

The purpose of this study is to discuss how to plan educational activities for the teaching-learning of BIM in the context of model authoring. This study is part of a research project which is aimed at introducing BIM courses in the architecture and civil engineering curricula in Brazil. As the adoption of BIM in Brazil is still in its early stages, there was a need to search for relevant documents in the international technical literature which discusses BIM education. Accordingly, 306 documents were analyzed using the 'Content Analysis' method [4] setting "educational activities" as one of the chosen 'Units of Analysis'.

2. Educational activities

Through educational activities, students can undergo experiences that are required for intellectual, and emotional changes and motoric development. Several variables may influence the choice of educational activities, such as: objectives; requisites; structure of the subject to be taught; phase in the teaching process; teacher's teaching experience; available teaching time and resources; and type of required learning [1].

When choosing teaching activities for a BIM course, it is important to consider their fitness to the objectives of the three BIM proficiency levels (see Table 1). For example, when the objective is to learn concepts of collaboration, the student should at first work with a more experienced colleague to acquire the necessary knowledge and later be introduced into integrated practices, first with students of the same course, and later with students of other programs. If schools do not have alternative programs to simulate integrated practice, they should use collaborative distance learning practices [2].

With regard to prerequisites, before working with students from other programs or universities, students should be educated about their professions and the roles played by members of a multidisciplinary team. They should also have previous experience and be given support on BIM [2]. If students from two or more schools participate, they should employ the skills and abilities of their professions. In the case of a multinational collaboration, several factors should be taken into account such as differences in schedules, in the school timetables, in culture, in building processes and materials, and in communication tools, besides the language difficulties [2].

Introductory	Intermediary	Advanced
Operate a BIM tool; Understand BIM Concepts; Explore basic concepts of modeling; Communicate different information; Use techniques of navigation in BIM; Produce documents and take quantities from the model; Differentiate types of objects and their behaviors.	Operate other BIM tools; Use advanced techniques for 3D modeling; Differentiate building systems; Explore features of parametric objects; Use BIM in the 4D and 5D processes; Conduct analysis using the model; Carry out simulations using the model.	Understand interoperability, BIM implementation and case studies; Operate BIM tools for management of the model; Understand teamwork and collaboration processes; Understand project execution; Know how the disciplines provide information; Know what information is needed in a process; Know when and how information can be exchanged.

Table 1 – Objectives of each level of BIM proficiency in the context of model authoring

To achieve educational objectives, students are exposed to several elements (facts, situations, theories, principles, concepts, processes, systems, etc.) which compose the subject structure. The relationship between these elements determines the type of learning needed by the student to understand a certain issue [1]. An example of this is the proposed teaching structure for the modeling process of a building throughout a BIM curriculum (see Figure 1).

The diverse topics in this structure demand different types of learning and, therefore, different teaching activities that teachers need to offer. This structure have been designed according to the objectives of each level of BIM proficiency which start with the modeling of a small building (or parts of one), followed by the modeling of a finished small building to which the students have access and culminates with the modeling of a complex building under construction.

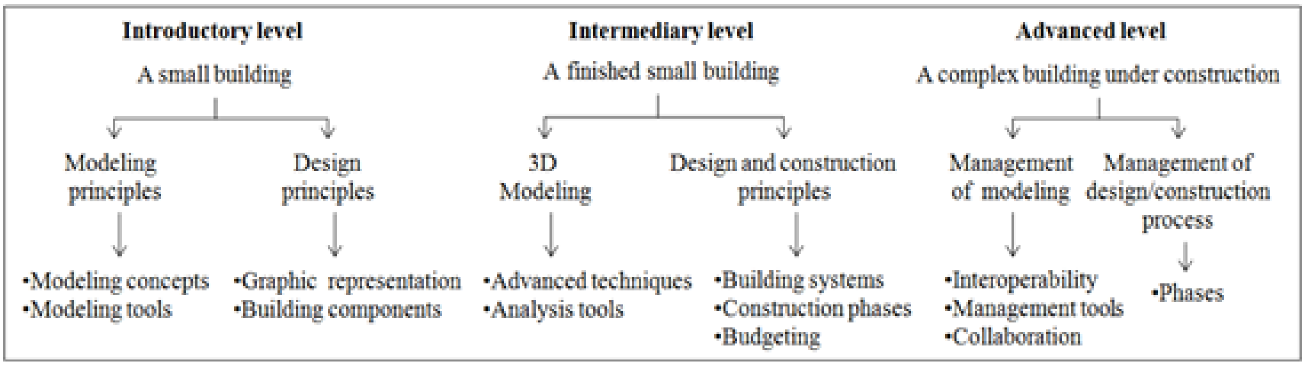

Figure 1 – Structure of BIM content throughout a curriculum

The phase in the teaching process determines the type of activity which is more suitable for learning. For example, when using the methodological approach of problematization with the Charles Maguerez' arc [1], there are five phases, starting with the observation of reality and problematization. For each stage to be reached, it is desirable that students develop certain skills to be accomplished with planned activities [1]. For example, in acquiring the ability to 'observe', the literature on BIM points out some of the related activities: technical visits to companies and construction sites; the use of virtual environments like games, teleconferencing and chat sites; the use of media such as public blogs, wiki and forums; programed instruction and directed studies such as digital text with self-assessment components; teaching BIM modules containing interactive exercises carried out with the participation of industry professionals, etc.[3].

With regard to the teacher's teaching experience, in the case of the Integrated/Interdisciplinary Design Studio, the team could have a coordinator, an assistant professor and a teacher/lecturer from each subject-area to provide assistance to students, as well as personnel from industry to give advice. The teacher of design need not know how to use a BIM tool, since the IT teacher has this expertise. Both teachers can give each other support. Experienced teachers from other universities may also be invited to take part in virtual courses and thus help the new teachers [2].

The teaching resources available must meet some requirements such as: BIM tools appropriate for each discipline, which support Industry Foundation Classes (IFC) data exchange, employed for various purposes. The classrooms should be designed for modeling activities, lectures, meetings, debates and giving presentations. Their environments must be equipped with video and multiple screens for teleconferencing. As the concept of interoperability is a major obstacle to implementing BIM in industry, the teachers should strive to support open standards. A single server is recommended to solve the problem of the file sharing, or cloud computing can be used [2].

Regarding time, in the case of an Integrated/Interdisciplinary Design Studio, it may be difficult to combine the schedules of teachers and students when organizing a course where participants are from different universities and even different time zones. However, the logistical challenges can be partly solved by working out a time schedule for some meetings involving all the classes of the design studio in the same physical (or virtual) space [2].

The type of learning required or the learning theory that will guide the teacher is also based on the principles adopted for the activities [1]. Problem-based learning and/or project-based learning are suitable for the development of BIM projects with teams of students. In project-based learning, the main activity is the development of a project and the contents are introduced as needed. The tasks are designed to reflect the professional reality of the situation and generally take more time than the tasks in problem-based learning. Another approach suitable for students in an advanced BIM course is role-based learning. In this approach, the teacher determines the problem to be studied in the task and the students play different roles. The students share the work among the group members by taking account of their specialist skills and weaknesses. They also control the content, the performance of the task and how it will affect its members. Although it leads to greater motivation, this learning approach may limit the student to learning only a specific role, instead of obtaining a clear image of all the roles and their relationships [2].

3. Conclusions

On the basis of the recommendations outlined here, the next phase of this study is to analyze the curricula of both, architecture and civil engineering undergraduate courses of the University of São Paulo in Brazil and plan scenarios for introducing BIM in existing disciplines. The proposal will be validated by BIM specialists throughout the discussion of these scenarios.

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During BIC conference a survey was conducted in order to get BIC participants' valuable opinion on BIM implementation and also on conference organization. The most relevant results are presented in the following sections.

5.1.Respondents characterization

The questionnaire distribution effort yielded 67 responses, which were distributed as presented in the following figures (Fig. 1 and Fig. 2).

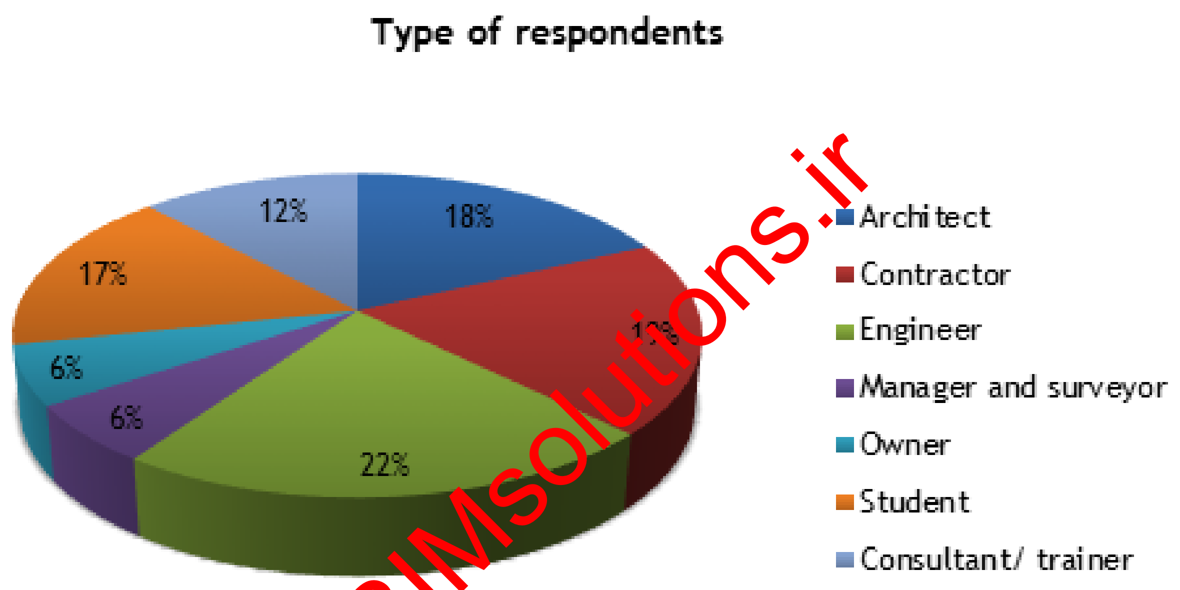


Figure 1 – Survey respondent distribution (by type)

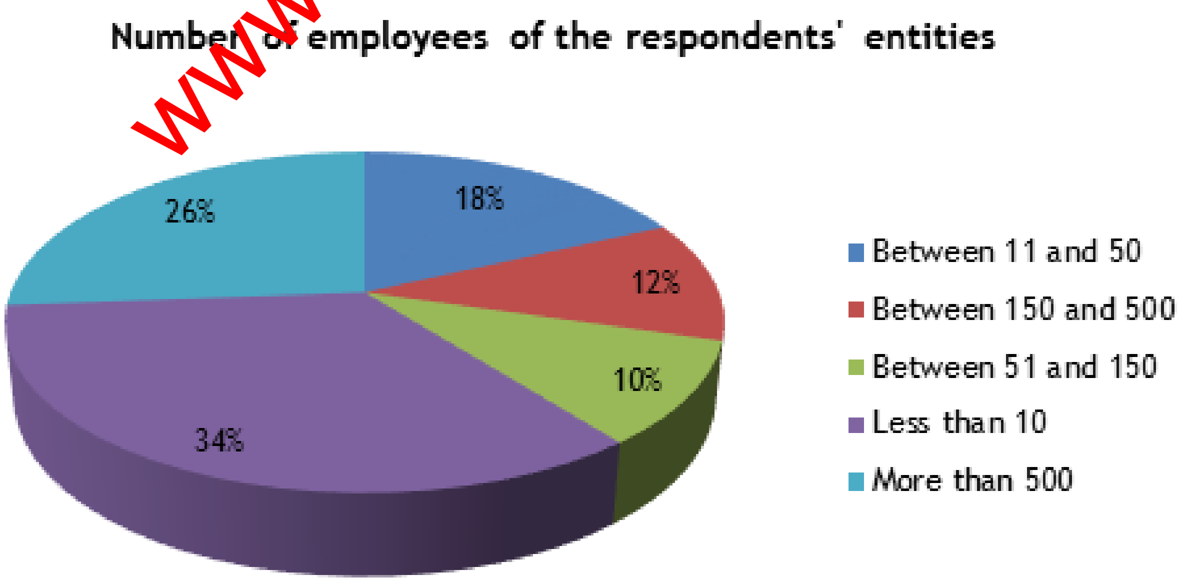


Figure 2 – Survey respondent distribution (by number of employees)

5.2. Major results on bim implementation

The first questions focused on BIM adoption and implementation level. The results show that the majority of the respondents have already adopted BIM but only 15% of them consider to have fully adopted BIM (Fig. 3). When we look to the BIM implementation level, we can see that 50% of the BIC participants use BIM in less than 15% of the projects. So, we can conclude from this results that although BIC participants are using BIM, they recognize that the BIM implementation level is still low.

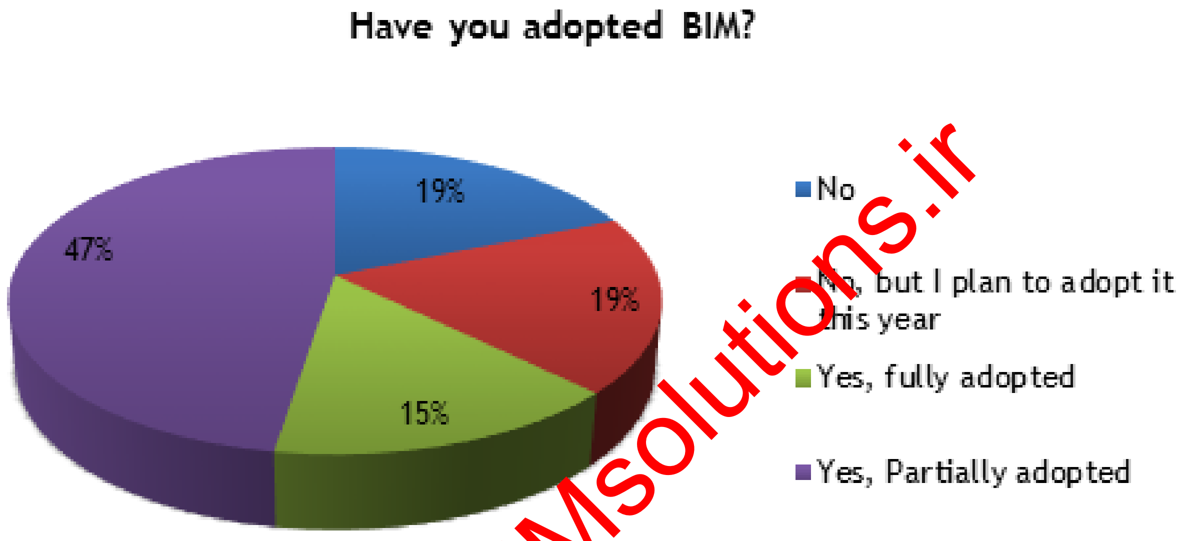


Figure 3 – BIM adoption among BIC participants

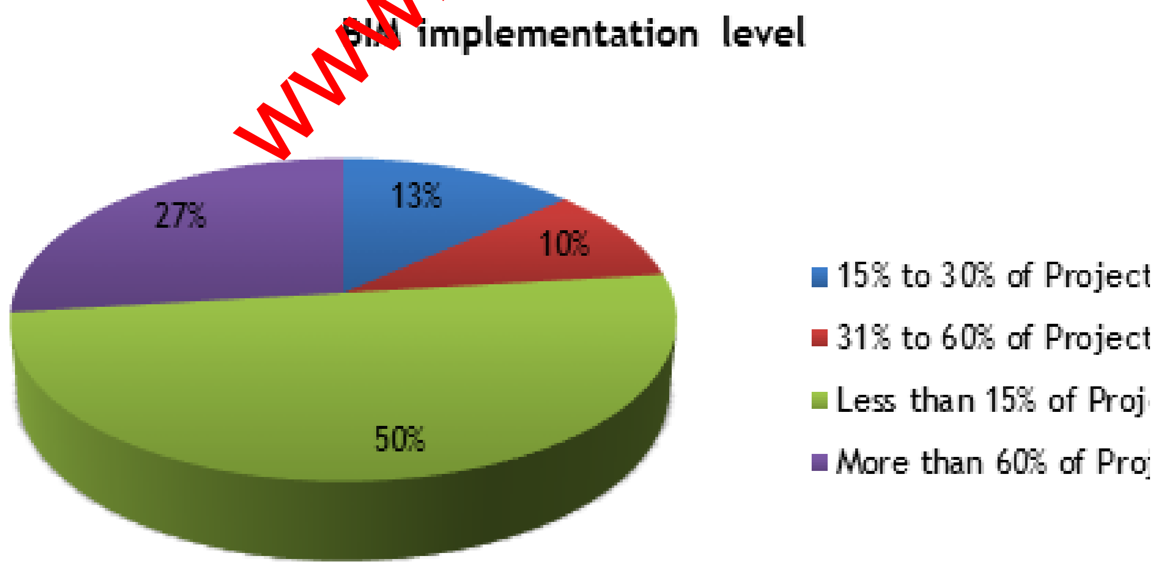


Figure 4 – BIM implementation among BIC participants

When we analyse BIM adoption based on the type of entity (Fig. 5), we can verify that among BIC participants the owners lead the adoption of BIM, followed by the architects and the contractors. We believe the owners are at the top of the list because only the owners who are "innovation leaders" and BIM enthusiasts participated in the conference (as it is possible to see in Fig.1, only 6% of the BIC participants were owners).

On the other hand, when we look at Fig. 6, which shows us BIM adoption by number of employees, we can see that smaller organizations may have more difficulties in adopting BIM.

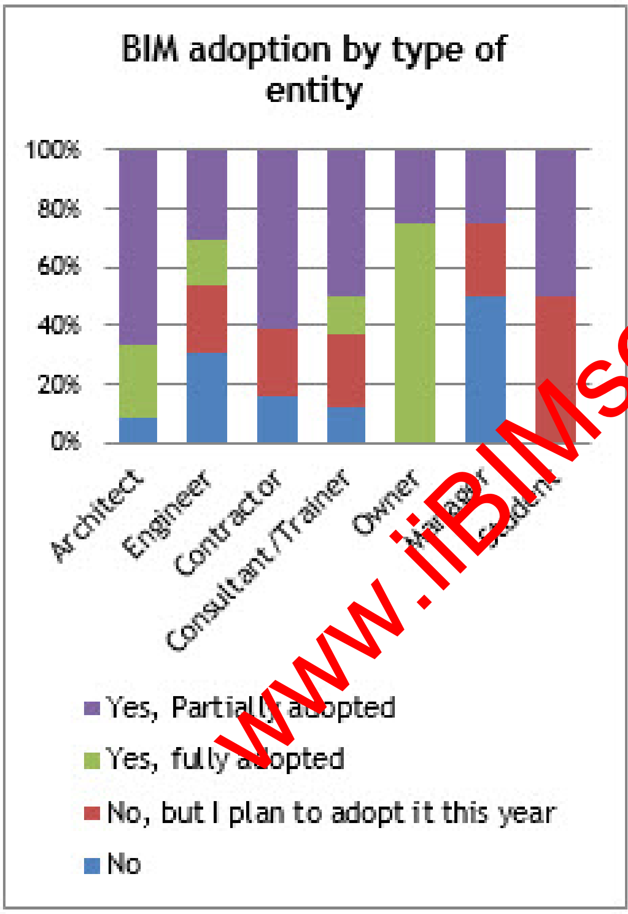


Figure 5

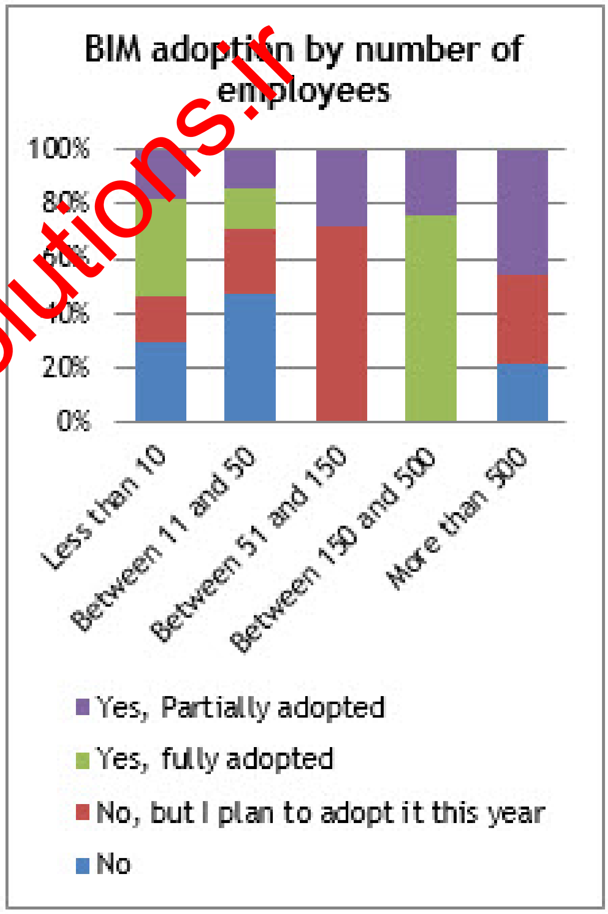


Figure 6

The results regarding BIM implementation, when analysed by type of entity and by entity dimension (Fig. 7 and Fig. 8) show us that owners and architects are, again, the leaders, closely followed by engineers and contractors.

However, when we analyse BIM implementation by entity dimension we can verify that small organizations are the ones with higher implementation levels, what might indicate that small organizations use BIM in their projects but only a small part of BIM's potential.

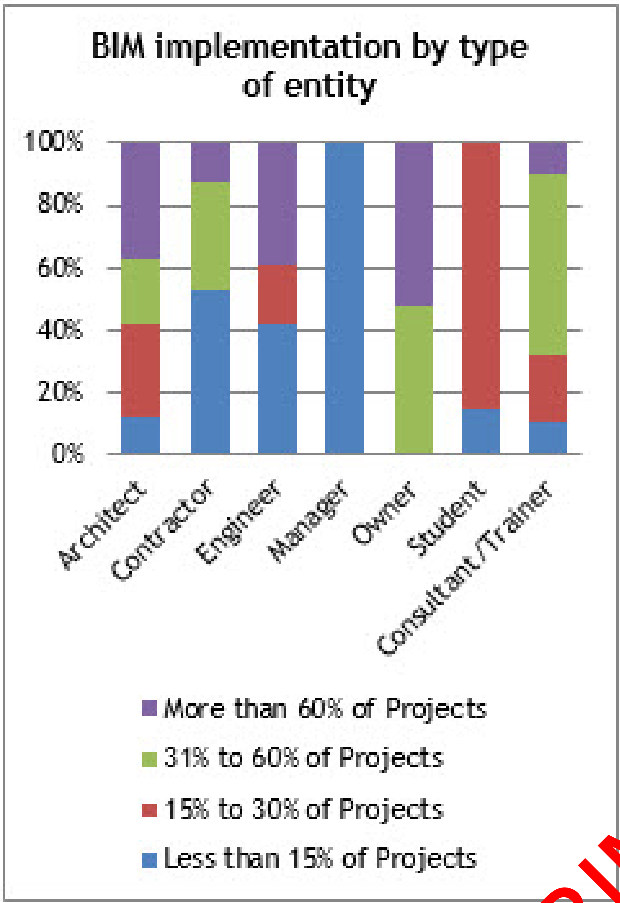
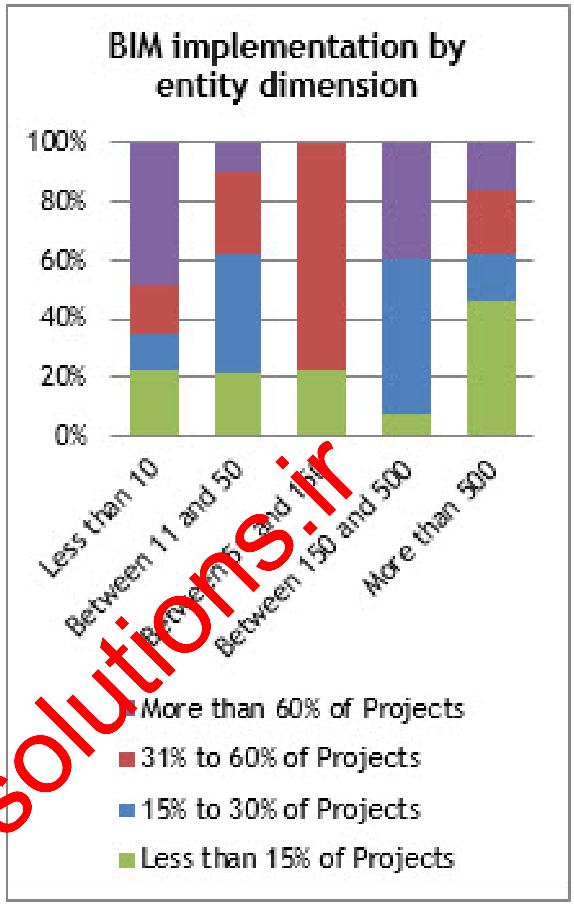


Figure 7



Figure

As it is possible to see in Fig.4, when we use a 10 point scale to ask what are the major medium/long-term BIM benefits, respondents show to be divided. However, responses demonstrate that staff recruitment and retention, new markets access, cycle times reduction, new services offering and rework reduction appear as the 5 most relevant benefits. So, it is possible to say that at the top of the benefits are evident the competitive reasons and efficiency concerns.

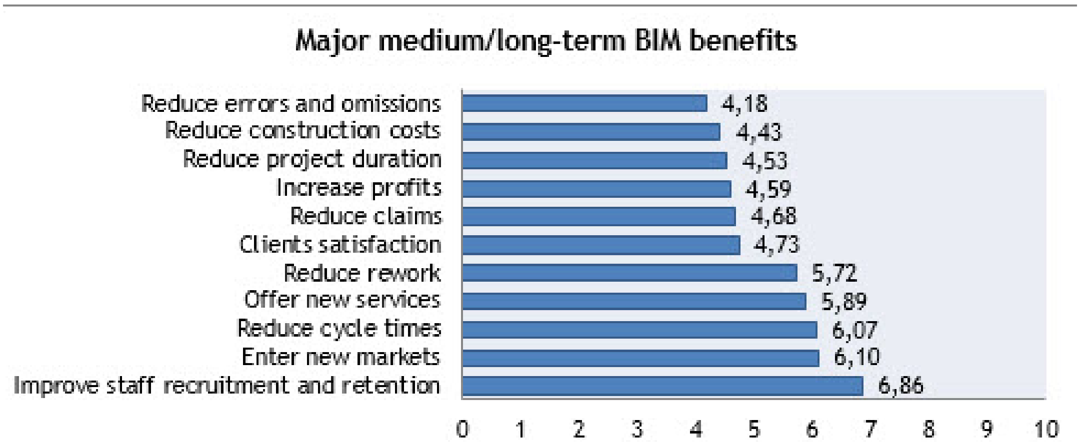


Figure 9 - BIM Benefits

Finally, the following figure (Fig. 10) allows understanding what motivates BIM adoption in respondents' organizations. It is interesting to see that the majority of the respondents refers that BIM is not required but it is encouraged. This result may show that the industry recognizes BIM potential although the clients do not mandate it.

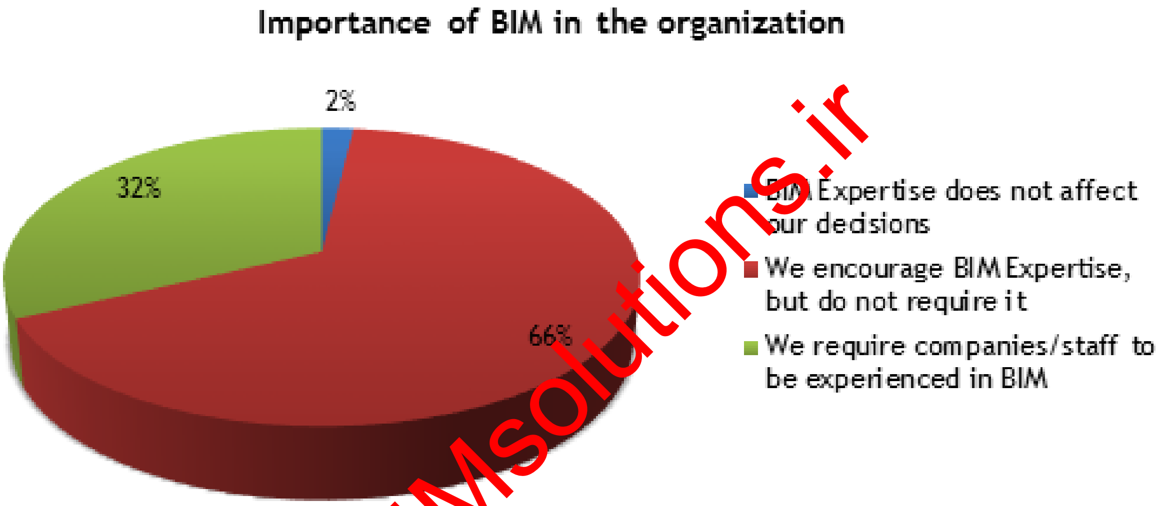


Figure 10 - BIM Importance

5.3. Conference evaluation

In the second part of the survey, the level of satisfaction regarding conference organization was analysed (Fig.11 to Fig.19). Considering that the 2nd BIC is already planned to the year of 2014 these results are extremely important envisioning potential improvements.

Overall it must be said that respondents considered tha the conference was interesting and well organized (most of the rates are above the average). Furthermore, it is pleasant to verify that 83% of the respondents plan to attend the 2nd BIC conference, which will be held in Lisbon.

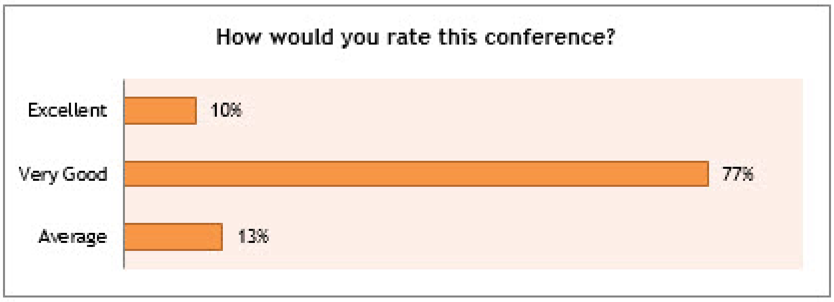


Fig. 11

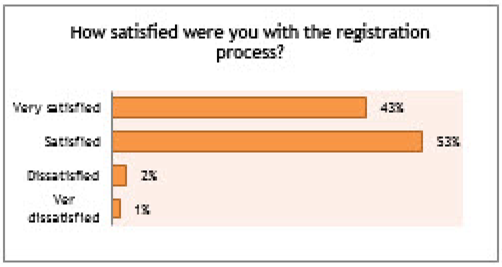


Fig. 12

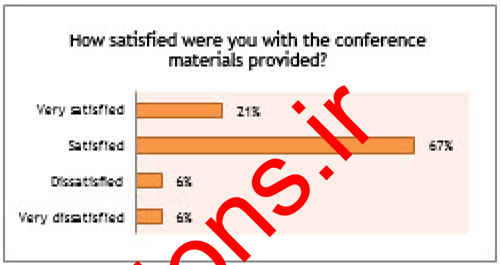


Fig. 13

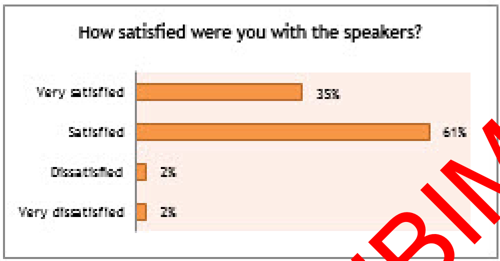


Fig. 14

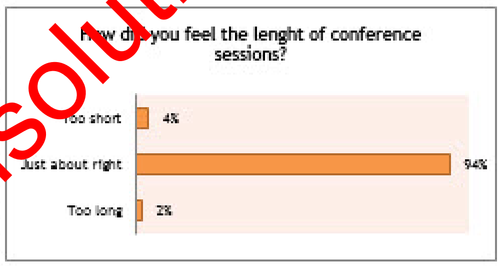


Fig. 15

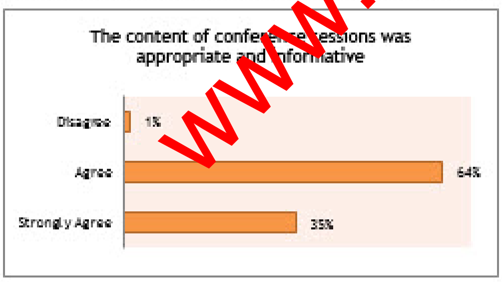


Fig. 16

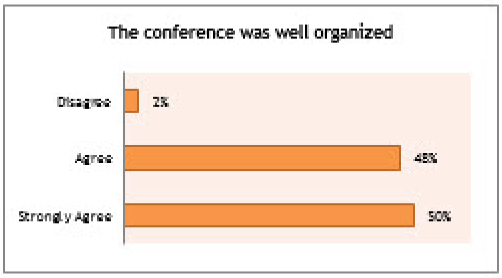


Fig. 17

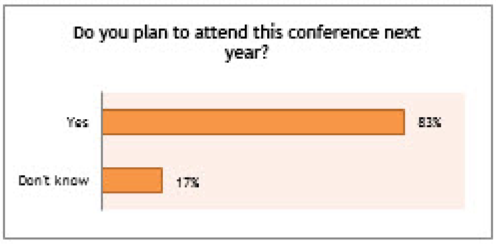


Fig. 18

Fig. 19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