BIC 2014

Building Information Modelling:
Challenges to Overcome

Proceedings of The 2nd BIM International Conference (BIC)

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BIMForum Portugal
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Phil Jackson

Member of UK Government BIM Taskgroup and Information Strategist.

"The 2nd BIM International Conference (...) was a great example of that coming together and cooperating to share and encourage good practice. The summary of proceedings included in this publication provides good material for industry players who wish to better use, develop and communicate the information that flows through any construction project, realizing the full potential of digital engineering. I commend it to you."

I have spent more 40 years in the construction industry and, over my career, worked on many projects both large and small. During that time one thing that has often struck me is how poorly the industry's multiple disciplines, skills and specialisms have communicated and coordinated within and outside their projects. Despite these imperfections, the construction industry has, and continues to, produce, amazing solutions that contribute to the overall infrastructure that supports our economies and social environment. Many of these large infrastructure projects, have impacted the lives of millions and the economies of whole regions and communities and I am proud to have been associated and worked with the people and organizations that have delivered them. Their combined efforts, knowledge and skills are something that we as an industry should be proud of. We now have a pressing need to deliver more of these projects that drive economies the life qualities of our increasing populations and to deliver them more efficiently and intelligently. In order to do this we need to overcome the limitations of our present communications and coordination processes harnessing the industries strengths into a more collaborative and joined up process.

Transferring information between the life cycle stages and players in the construction industry has traditionally been by the use of paper be it physical or electronic with all the data and information that has been invested in by each skilled player locked into that paper. If we could only liberate that data and the in-built investment of time, effort and intellect to all the stakeholders in an asset whether they are the public, strategist, planners, designers, constructors, fabricators, artisans or operators then our outcomes would, I believe, improve significantly. It is in that space that Building Information Modelling (BIM) is maturing towards playing a valuable part in achieving. Particularly as it and our understanding of it develops and its full potential is realized. Having started life, and been promoted as, a technology that concentrated on 3D object modelling BIM is now emerging as the tool that liberates information and stretches far beyond those early visions of parametric geometric models to one that acts as an information spine that runs through the lifecycle of our built environment.

Indeed its potential should now be seen in wider context of 'Information Management' and it's probably time to drop the building and modelling from the title?

One significant thing that has been realized as we experience and develop our implementation of BIM is the need for clarity in what information each industry player requires and how that information can be created, captured, communicated and managed reliably and consistently. Often the reason that communication and coordination in the industry has been poor is because the 'Information Requirements' of each stakeholder has not been clearly expressed and articulated. If we know what information we each need, when we need it and why then our ability to collaborate and coordinate will be greatly enhanced. If we can collect that information in an 'open' and standard, controlled way then our use of it will add significant value and help realize the potential of BIM. The future will then be not one of single project/asset model, or a single piece of software, but one of a pool of structured information that clever people and clever applications can draw on, share and add value to for all to benefit. In summary of the enabling the whole supply chain becoming 'Digital Information Engineers'

Achieving these goals and delivering the full potential of BIM will require standards, improved processes and improved underlying technologies. However the most significant obstacle to achieving the goals lie in developing people, changing attitudes and people skills to make the most of this newly liberated joined up data. Making that change throughout the industry from the large clients down through to the artisans and small suppliers that our industry rely upon presents a big challenge and one that will only be achieved as we share good practice and collaborative attitudes. Organizations and conferences that join people together across the industry internationally have an important part to play in fulfilling the potential of BIM and achieving the ultimate goal of better outcomes in the delivery and operation of our built infrastructure.

The 2nd BIM International Conference held in Lisbon in October 2015 was a great example of that coming together and cooperating to share and encourage good practice. The summary of proceedings included in this publication provides good material for industry players who wish to better use, develop and communicate the information that flows through any construction project, realizing the full potential of digital engineering. I commend it to you.

1. Introduction

The mission of BIM Management Institute is to promote and accelerate the adoption of Building Information Modeling (BIM) in the construction industry.

Today, there is a greater consciousness regarding the importance of this topic; scientific research and practical experience which leads to a better understanding and knowledge of better ways to manage resources and information, were in the genesis of this BIM concept. The interest of the international scientific community and industry is clear. And we can see that our networking is increasing every day.

Due to the fact that Portuguese government concerns are more related with short term problems, we have been unsuccessful on getting their aware about BIM importance for the construction industry. This is a fact that we understand if we take in account the basic problem that Portugal, as other countries face.

So we will make BIM Management Institute Initiative even more open and collaborative and we will challenge all of you from Portugal and other countries to join this effort. Together, with the effort of everyone, we will manage to develop a good standard shared and recognized among countries.

Today we have a platform (www.bimmi.org) that is a social network that supports and give the tools for the exchanging of knowledge and the launch of challenges and collection of ideas for future international R&D projects and standards.

This second edition of the Conference has attracted more than 200 participants from more than 20 countries. We heard 16 keynote speeches, and had the opportunity to see about 36 abstract presentations. The subjects ranged from government initiatives to architecture and engineering, construction management, facility management, openBIM and research. We are sure that the selected topics provided the participants with a wealth of information and many opportunities for discussions.

On the first keynote session, national initiatives, we had the point of view of four experienced professionals on the challenges and possibilities in the built environment and the strategies that should be developed to encourage and keep pace with beneficial change. The questions of what a government should (and shouldn't) do, the need of new contract forms and requirements as well as the importance of rigorous processes and procedures were addressed on this session.

The second keynote session gave us an overview of the BIM status with respect to Architecture and Engineering in different countries. Reputable designers will share with us their experience and difficulties felt on the transition from 2D to BIM and the new technologies available.

On the second day, the first keynote session was themed "Construction Management" and the speakers gave a deep overview on what is 5D BIM, its' advantages but also difficulties in such implementation.

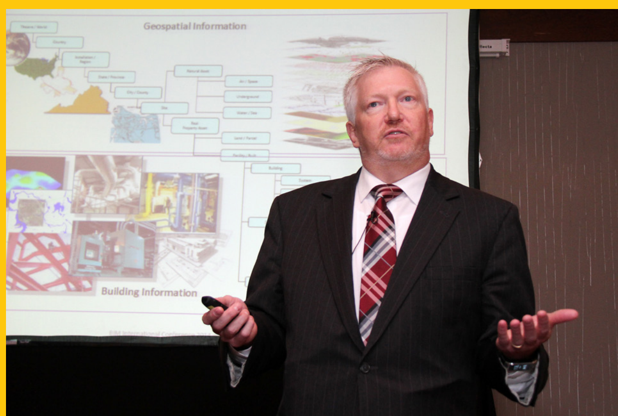
The second keynote session, introduced what is already known of 6D BIM. The obvious next step for BIM is to approach the facility management. The Keynote explored what is the state-of-the-art of FM and how an owner can begin to utilize BIM to increase efficiencies in their buildings, to manage its assets and day to day operations.

The last keynote session helped us to figure out what is the importance of OpenBIM and gave an example of why research done by universities could have an important role in this paradigm change.

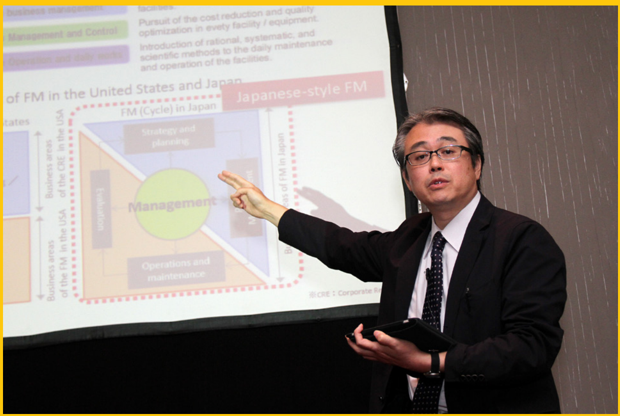
The already mythic social events this year were at Medeiros e Almeida Museum that was preceded of a guided visit to this house museum, and the closing party was at Torreão Nascente at Praça do Comércio. Both were a great opportunity for participants to exchange contacts and knowledge.

The challenges made by the Conference are significant, but we are confident that the industry will succeed in our objectives. We wish to see you next year on BIC2015, the first edition that will be divided between two cities, Oporto and Madrid, during 3 days full of great keynotes.

2. Keynote Speakers



2.1 Keynote Speakers



Haraldur has a BS.c in architecture and construction management from VIA University in Denmark and a master's degree in Building Informatics from University of Aalborg, Denmark.

Haraldur is working as a BIM specialist for the Government Construction Contracting Agency (GCCA) in Iceland. He is also managing director for BIM Iceland which is a government initiative to implement BIM in Iceland. His background from the construction site and from the software industry has given him a good overview of what opportunities are available for implementing BIM in Iceland.

Haraldur Arnórsson, Managing Director of BIM Iceland, a government initiative

Title: BIM Implementation in Iceland

Main content: Iceland has only around 320.000 inhabitants and the building industry in Iceland could be considerate as micro market compared to our neighbors. Therefore the government has to take different approaches in implementing BIM. The size of the market can also work in our favor and even make us attractive for software vendors to test their products.

Main topics:

- History of BIM in Iceland
- What is being done to implement BIM in Iceland
- What has been the main obstacles
- What are the goals
- Where are we now

Steen is a Managing Director of buildingSMART Norway Office since 2010.
Educated Architect from Copenhagen Royal Academi of Fine Arts. Worked as Architect and project manager for 13 years. Sunesen is convinced that technology will and has to be the foundation on which we modernize the old fashioned and ineffective building industry.
Since 2000 Sunesen worked with BIM and was the architects project manager of one of the first built openBIM project in the world, the Entrance building at Ahus University Hospital in Norway. Sunesen has been central for a number of development project aiming to make openBIM useful for the Industry. Both in the national and international buildingSMART and standardization bodies.

Steen Sunesen, Managing Director of buildingSMART Norw ay Office

Title: Building an openBIM Nation

Main content: Drivers that make the Industry change to openBIM and how the change can be centered around a local buildingSMART chapter
buildingSMART Norway coordinate the business' openBIM initiatives, standardize best practice and educate the Industry.
The Norwegian industry established the first member based openBIM organization in 1995. Today buildingSMART Norway has a professional secretary and an annual budget of EUR 500.000. And we are working to double this within the next three years.
The road from grassroot to established organization has taught us how to organize and fund a national arena for openBIM.

Main topics:

- The value of organizing the openBIM efforts
- The Norwegian experience from organizing the industry
- The Industry's need for education and the Norwegian solutions
- Standardizing and communicating best-practice

Diderik Haug is working in the R & D section in Statsbygg as a Senior Engineer since 2006, he has been the projectmanager, in Statsbygg, for the development, and implementation, of BuildingInformationModels based on open international standards. (BIM with the IFC). Statsbygg is nationally and internationally leading in the use of this technology, and Diderik Haug is widely used as a speaker nationally and internationally.

Diderik Haug has a degree in engineering from the University in Stavanger. He is an experienced projectmanager, with long and broad experience in the building industry. He has worked onsite with construction for 17 years and 14 years as a projectmanager in Statsbygg with larger projects up to 80 million euros.

Diderik Haug, Senior Engineer of R&D section in Statsbygg

Title: BIM experience in Statsbygg Norway

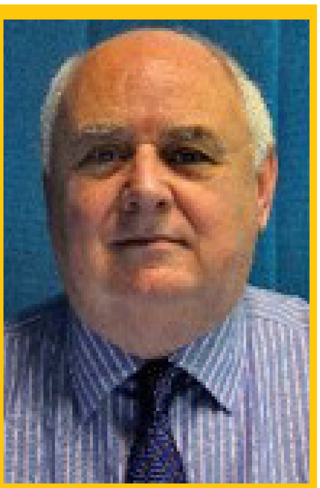
Main content: Why do Statsbygg use BIM in there building projects today How do Statsbygg use BIM in in the building projects today.

What is the most important development of BIM for Statsbygg in the years to come. LOD, Processes supported by BIM, data formats, existing buildings.

Main topics:

- Improving Quality in planning, in production, in use and in decision making improved understanding among all participants in the project

Phil is a Fellow of the Institution of Civil Engineers with many years of practical experience in design and construction. He is an acknowledged leader in the deployment of Information Technology in Infrastructure Design, Construction and Operational Management.
He has been involved in some of the world's most prestigious projects, like the UK Channel Tunnel, Hong Kong's Airport or the London Crossrail. He is a member of the London Crossrail BIM Advisory Panel and has been working with the UK BIM Taskgroup as a core team member. He runs his own independent consulting company and is Royal Academy Visiting Teaching Fellow at the University of Surrey. He also chairs the Institution of Civil Engineers Information Systems Panel, is a board member of Building Smart UK, and serves on a number of standards steering groups related to BIM.



Phil Jackson BSc CEng FICE FRSA

Title: Apply BIM to Infrastructure Assets

Main content: BIM has gained wide acceptance in design and construction for buildings however the use of BIM in infrastructure is less mature and requires amore 'Life Cycle Asset' approach to its application. This presentation will address some of the aspects of applying BIM to design construction and management of infrastructure assets particularly in roads and environment. Drawing on experience from working with the UK Highways Agency and Environment Agency it looks at the life cycle approach to information management and the issues of discretisation of continuous assets the progressive production of information. It will explore how we have used the COBie approach to capture infrastructure data and take a peak into the future requirements for infrastructure BIM applications.

Main topics:

- Asset Information Life Cycle
- BIM Industry Requirements Diversity
- Decision Based Processes
- Dealing with non discrete assets
- Topological and contiguous BIM
- A peak into future application requirements

Rob is an Associate Director and qualified Architect at Bond Bryan Architects (UK) and has delivered projects in the Education and Advanced Manufacturing sectors.
His significant project experience and passion for process and technology resulted in his selection for a number of special projects for the practice including the development of the quality systems and office intranet facility. This work then led to his current role of BIM Manager.
He speaks at both national and international events as a passionate advocate of an open BIM approach, exploring the sharing of data between different software packages via the "IFC" open format and promoting industry wide standards that enable full collaboration between different parties.
He chairs the sub-committee for the AEC (UK) BIM Protocols for GRAPHISOFT ArchiCAD, is a member of the buildingSMART UK's Technical Group, an ambassador for thinkBIM at Leeds Metropolitan University, tweets as @bondbryanBIM and also writes our BIM Blog.

Rob Jackson, Associate Director and qualified Architect at Bond Bryan Architects

Title: An OpenBIM journey part 1: Interoperability

Main content:
Bond Bryan Architects have authored models since 1994 and since 2007 have exchanged models with other consultants. 2011 saw the UK government announce that publicly procured projects will be required to deliver BIM from 2016. This sparked uptake in the UK but many thought that "BIM is Revit". This represented a significant threat to the business as Bond Bryan Architects were not using this specific tool. This is the story of our interoperability journey and how we tackled and continue to tackle this threat.

Main topics:
- The challenge to overcome and the options to satisfy this challenge
- Successes and failures of exchanging models between different software
- Examples of files and projects used in file exchange
- Benefits of the openBIM approach to our business

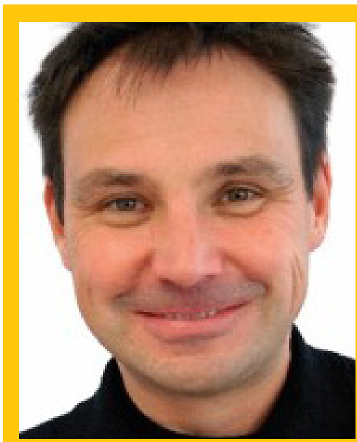
Heikki has a Master of Science in Arhitecture at Helsinki University of Technology (today Aalto University)Member of Finnish Association of Architects and Finnish Association of Hospital Technology.
Architect Heikki S. Laherma has 29 years of experience in architectural design within the fields of healthcare, social care and welfare sector as well as over 35 years of experience in other aspects of architectural design. He has worked as a principal designer for 29 years.
He was the MD of Studio Laherma & Wallenius Oy from 1992 and 2010 he was appointed as MD of Sweco Paatela Architects Oy (from 2013 Sweco Architects Oy).
His main roles in the health care design today are:
Feasibility studies, project programming, concept design, functional design and building design. Projects consists of both new buildings and renovations.
He has designed several projects for Helsinki University Central Hospital, the city of Helsinki, Kuopio University Hospital and other public and private clients.
Laherma has also given lectures on hospital design in many conferences both in Finland and in Europe.

Heikki Laherma, MD of Sweco Architects Oy

Title: Tools in Hospital Design

Main content:
In Finland there are 20 Health Care Districts an five University Hospitals which will invest over 5,4 billion € in the next ten years.
There are many reasons for this. One is the fact that the existing hospitals are getting technically old. Another reason is that this year there came the new law that gives patients the right to choose their hospital or health care center. There will be in the future also a competition of health care professionals.
These factors mean that the new or renovated hospitals should be designed in such a way that they can fulfil the new demands.
With BIM and 3D we can not only resolve the technical questions of the building but concentrate on architecture and most of all work with the client and medical staff in an interactive way and demonstrate the results of the design in a more comprehensive way.

Main topics:
- to understand and develop the environment of the healing processes
- to design a healing environment
- to design a pleasant working environment
- co-creation
- cave as a 3D tool



David has worked at the highest levels of design in both the UK and abroad and is passionate about progressive architecture, emerging technology, design and delivery excellence. Before setting up the practice in 2000, he worked in the offices of Norman Foster and Santiago Calatrava, then became an Associate Director of Future Systems, where he was Project Architect for the Stirling Prize-winning Media Centre at Lord's Cricket Ground.

His specialist design knowledge and delivery of complex buildings evolved into an interest in three dimensional analysis and modelling. This led him to develop the use of 3D software to enhance building design and the architectural team use this technology to search out delight and proportion in solutions to every day problems.

Under David's leadership, the practice is acknowledged as a UK expert in BIM techniques. He works directly with the Government's BIM Task Group supporting their implementation programme and he champions the CIC's (Construction Industry Council) London BIM Hub as well as sitting on the RIBA's Practice & Profession Committee advising on BIM adoption in architecture.

David Miller, Director & Principal Architect

Title: Aligning a small practice with a BIM workflow

Main content:

The intention is to demonstrate what can be achieved by a small business through the alignment of BIM tools and streamlined business processes and how this can lead to repeat business and client and staff satisfaction. The presentation will describe the evolution of a small architecture practice into a BIM centric enterprise model as a response to the UK government's mandation of Level 2 BIM by 2016. The presentation will be in two parts. Firstly exploring why change was necessary, the process undertaken, and the outcomes for the practice, both economically and culturally. The second part will illustrate by example the productivity and efficiency gains enjoyed on a new school project, including how the BIM process has fed into off-site manufacture.

Main topics:

- Structuring an office around a customised BIM workflow
- Leveraging efficiencies to underpin investment in R&D
- Embedding BIM workflows in to a Best Practice Management System
- Approach to training and continuous upskilling
- External measurement and validation
- Business performance metrics

Tibor has been working for GRAPHISOFT since 1998. During these years he held various positions in the company, he started as a GDL Developer, he was leading the Object Library Team, for several years he was a Product Manager and most recently he works as a Business Development Manager. His current tasks involves BIM Implementation Support for key customers, the management of GRAPHISOFT's Registered Consultant Program and the coordination of the company's training and education activities.

Tibor holds an M.Sc. in Architecture from the Technical University of Budapest. After graduation he has completed a 3-year PHD course on Computer aided design methods in architecture".

Tibor Szolnoki, Business Development Manager

Title: Overcoming Communication Barriers

Main content:

Recent surveys shows that there is an increasing need for more efficient collaboration and communication methods in the construction industry. BIM based teamwork methods, such as the GRAPHISOFT BIM Server, provide advanced communication platform for the members of the architectural design team. How can we extend these capabilities for those who work in other sectors of the construction industry? How can we communicate with those who work remotely on a construction site?

GRAPHISOFT's BIMcloud service together with the next generation BIMx mobile application provides a really unique solution for these challenges. The presentation will give you a sneak preview of this revolutionary new solution set.

Main topics:

- Communication Challenges of the industry
- Coordination and Collaboration between architects – GRAPHISOFT BIM Server
- BIMCloud for global design practices
- Communication on the construction site - BIMx

Joyce obtained a double degree in Architecture and Civil Engineering at University of São Paulo, and is a certified Project Management Professional by the PMI. Currently she is developing hers master's dissertation on the topic of BIM technology.

She has been involved on technologies and implementation of BIM methodologies since 2007. She worked at Autodesk do Brazil where she taught on the topic of BIM for large companies such as consultant firms, contractors and owners.

In the past 6 years, she has worked at Metodo Engenharia, an engineering, project management and construction company, where she is responsible for the BIM technology's management and implementation. She is a member of the BIM-AsBEA Technical Group and a member of the ABNT/CEE-134 Technical Committee responsible for the development of industry standards on Construction and Building Information Modeling (BIM) in Brazil.

Joyce Delatorre, BIM|VDC Coordinator at Método Engenharia

Title: BIM at Método Engenharia: From Design to Construction Management

Main content:

Well recognized as a pioneer in the implementation and use of BIM in Brazil, Metodo Engenharia recognizes the importance of the application of new technologies such as BIM as a way to improve the quality and efficiency of its project management.

Through the presentation of cases in which this technology was applied at Metodo Engenharia, we will demonstrate the advances brought by the BIM implementation, its main objectives and results.

Main topics:

- BIM Implementation Process at Método Engenharia
- Case 1: Coordination and Clash Detection
- Case 2: 5D Implementation

Ian Warner recently joined Trimble in August 2013 as a field solutions sales and support specialist for Trimble's GCCM Group and is currently heading up the technology integration plan for future Trimble buildings. Previously, he was the Field Technology Manager for JE Dunn Construction Company on the Trimble Westminster Office Building near Denver, Colorado. Before joining JE Dunn, Ian received several degrees from The University of Kansas including dual Bachelors in Business Administration and Architectural Studies, and a Master's in Architectural Management with an Emphasis in Design-Build Construction Management. He joined JE Dunn in 2002 as a Project Manager and transitioned to the Superintendent Trainee Program in 2004 where he worked his way up through the ranks to become a Journeyman Carpenter and Superintendent.

During his 11 years in the JE Dunn Rocky Mountain Region, he has helped manage a wide variety of projects including several complex hospital projects. The cumulative 21 years of construction experience has strengthened his belief in the implementation of emerging technologies including robotic total station layout, laser scanning, accurate Building Information Modeling, and construction management software.

Ian Warner, Support Specialist for Trimble's GCCM Group and former Field Technology Manager for JE Dunn Construction Company

Title: Construction Technology Implementation on Trimble's Westminster, CO Phase 1 Building

Main topics:

- Issues with Traditional Design, Construction, and Operating Processes
- Importance of Technology and BIM Implementation Plans
- Various BIM Programs Used on the Westminster P1 Project
- Fundamentals of Intelligent Positioning for a Project
- Emerging Technologies

David is a Fellow of both the Royal Institute of Chartered Surveyors and Chartered Institute of Building, he also has a master's degree in Property and Construction Management.

He has over twenty years practical experience in the construction arena. David's enthusiasm lies in highlighting the potential of new technologies and how we interact with them to bring added value to our customers and unlock new ways of working throughout the entire life-cycle. David is passionate about our industry and perceives BIM as being a catalyst for reform.

An early adopter of practical change and purposeful collaboration, David is currently seconded to the UK BIM Task Group as Head of BIM . He is also chair of the BIM2050 BIM4 steering group and BIM4Clients.

David is also Head of BIM and Operations Director at Mace a global consultant and contractor.

He is a Professor at Glasgow Caledonian University and visiting Professor at Middlesex University.

David Philp, Head of BIM – UK BIM Task Group

Title: A whole sector approach to BIM

Main content:

It has been three years since the UK Government mandated level 2 BIM on all centrally procured projects by 2016. This presentation will explore how the UK both client and supply chain has unlocked the value proposition of collaborative level 2 BIM at all stages of the asset life-cycle through case studies from the BIM4 communities. It will also examine the economic case for a digitation of the built environment and do some future gazing as how we might transition to a digitally integrated sector that is technologically advanced.

Main topics:

- Digital transformation in the built environment
- Developing BIM maturity in the UK
- BIM4 – realisation of outcomes
- From collaboration to integration – futuregazing

Bill **is a serial innovator whose latest invention, COBie, is an emerging internationally standard. In 1984, Bill developed the first mini-computer based construction management system used by the Corps of Engineers. In the late 80's, Bill developed the standard for cost-loaded schedules used to pay every Corps of Engineer's construction contractor. This format continues to be used today. In the early 90's after teaching scheduling at the University of Illinois, Bill developed the CPM schedule training site, CPM-Tutor.com. Bill then developed the Design Review and Checking System (DrChecks). COBie is now an emerging international standard. To support the testing and evaluation of open BIM standards, such as COBie, Bill led the development of model views for HVAC, plumbing and electrical systems, common BIM files, and life-cycle business case validation methods.**

Bill has received awards from FIATECH, NIBS, CSI, Corps of Engineers, General Services Administration, and Government Executive Magazine. He is a former ASCE Government Civil Engineer of the Year. After a 35 year public career, Bill founded Prairie Sky Consulting to start new private projects and provide consulting services to align the people, processes, and technologies necessary to implement COBie.

Bill East, Prairie Sky Consulting

Title: Overcoming Innovation Barriers

Main content: A 1983 report of the US National Academy of Sciences stated that "much valuable data associated with the design, construction, and operation of a facility are lost during its life span." The question I have been struggling with is, "Why are we all still talking about this same topic 3 decades later?" For me the answer lies a lack of rigor in our industry. Private industry continues wasteful processes, even if improvements increase profits, as long as invoices continue to be paid. Most public owners are afraid of industry backlash if they try anything new. Software companies add new features, unable to identify consensus requirements. Researchers rehash the same problems without resolution. Associations become increasing insular failing to act on the interests of their members. This presentation provides a personal story of navigating these constraints while trying to create and sustain innovation to improve the quality of our built environment and the lives of those who create and use it.

Main topics:

- Technology Transfer Examples (from Henry Petroski)
- Innovation Pressures (Research, Practice, Owners, Developers, Social/Political)
- Accelerating BIM Research (CIB W078 Workshop Series)
- Turning Waste into Profit (Value-Added Analysis)
- The Commercial Software Cycle (Requirements, Configuration, Monetization, and Lock-in)
- Innovation Goals versus Mission Statements (Measurable Outcomes)
- Standards for Innovation (Standards create markets)
- Setting Innovation Goals (Or wait another 3 decades?)

Kazuki Matsuoka graduated from Kogakuin University in 1990 and joined Toda Corporation in the same year.
He has since worked in design, HVAC engineering, construction documentation and management, cost management, and project management. He played an integral role in introducing 5D and 6D BIM to Toda. Currently he is BIM-CM Project Manager, and has worked on office, residential, and hospitality projects.
Mr. Matsuoka is a member of the Japan Project Management Association, the Japan Construction Management Association, and the Japan Facility Management Association.

Kazuki Matsuoka - TODA Corporation, Japan

Title: BIM-FM SYSTEM FOR JAPAN

Main content:
Toda Corporation has developed a new BIM based Facility Management system that can monitor everything from maintenance and asset depreciation, to energy consumption and CO2 output. It is based on archifm.net, produced by vintoCON, and works with Graphisoft's ArchiCAD BIM authoring software.
By replacing 2-dimensional drawings with a BIM model, it becomes easier for stakeholders to understand the building itself. The BIM model can also act as a central database for building related information needed for strategic facility management. Workflows are established and built into the Facility Management system to facilitate ease of use and information sharing via dashboards and reports. Additionally, the archifm.net based software is linked to Toda's proprietary CO2, Energy, and Gas monitoring system CO2MPAS.
The presentation will include an overview of this system, as well as a discussion of the history and current state of BIM and FM in Japan, as well as a short introduction to the work of Toda in Japan and abroad.

Main topics:
- Description of FM in Japan
- BIM / FM in Japan
- Overview of Toda's BIM-FM SYSTEM
- Functions our BIM-FM SYSTEM
- Future prospects

Pedro Ló é membro fundador e atualmente Presidente da Associação Portuguesa de Facility Management (APFM) e Managing Partner na W.Space Facility Management desde 2010.
Pedro Ló tem experiência como Diretor da PT PRO em Shared Services por 4 anos e Project Management da Portugal 2004. Formado em Engenharia pelo Instituto Superior Técnico (1986), tem uma pós-graduação no Mestrado em Construção, em 1992.

Pedro Ló, Presidente da APFM -
Associação Portuguesa de Facility Management

Title: Closing the Gap Between BIM and FM

Main content:
Building Information Modelling (BIM) is currently a hot topic between FM practitiones.
Although it is easy to state that it brings powerfull advantages and benefits to all of the built environment supply chain, it's adoption is being it very slow.
Last year in a survey conducted by a group of British Institutions (BIM Task Group) to FM professionals resulted in very challenging discoveries, such as when asked "Do you believe that BIM will help support the delivery of FM?", 62% said "yes" and 35% said they were "unsure"...
When asked what were they're concerns, the top answers were: Cost (initial investment but also cost of managing and maintaining the streams of information); Integration with currently technology and CAFM; Training; Data Management; Time; Unknown Technology and Legal Issues.
How to join all stakeholders and overcome these challenges is a process in which APFM wishes to participate actively.

Main topics:
- Obstacles for BIM adoption
- The Facilities Manager' Whishlist
- The Road Ahead: adoption of BIM by the FM community

Rob is an Associate Director and qualified Architect at Bond Bryan Architects (UK) and has delivered projects in the Education and Advanced Manufacturing sectors.

His significant project experience and passion for process and technology resulted in his selection for a number of special projects for the practice including the development of the quality systems and office intranet facility. This work then led to his current role of BIM Manager.

He speaks at both national and international events as a passionate advocate of an open BIM approach, exploring the sharing of data between different software packages via the "IFC" open format and promoting industry wide standards that enable full collaboration between different parties.

He chairs the sub-committee for the AEC (UK) BIM Protocols for GRAPHISOFT ArchiCAD, is a member of the buildingSMART UK's Technical Group, an ambassador for thinkBIM at Leeds Metropolitan University, tweets as @bondbryanBIM and also writes our BIM Blog.

Rob Jackson, Associate Director and qualified Architect at Bond Bryan Architects

Title: An OpenBIM journey part 2: Information, information, information

Main content:

The construction industry in the UK has begun to move towards BIM in preparation for 2016 when all publicly procured projects will be required to deliver BIM. However many still fail to realise that BIM is far more than just building 3D discipline models for coordination and clash detection. The key component of BIM is the information that can be produced and used by others to improve project outcomes. This presentation therefore focusses on how Bond Bryan Architects have developed processes for creating open reliable data outputs.

Main topics:

- Why create information?
- What information to create?
- Creating and working with information
- Exporting and sharing information
- Checking, validating, quantifying and reporting information

Peter Katranuschkov holds an MSc degree in Civil Engineering from the Sofia University and a PhD in Construction Informatics from the TU Dresden. His professional career involves work as structural designer, software developers, construction informatics researcher, BIM specialist and RTD project developer and manager. Since 1993 Peter works on the promotion of BIM technology and the conception, dissemination and extension of the IFC standard. He was among the first developers of the initial pre-IFC models produced in the 90s by research projects like COMBI, ATLAS and ToCEE and one of the chief developers of the IFC structural analysis extension and the IDM methodology.

In the last 20 years Peter has participated in more than 20 large national and international BIM-related RTD projects and has published over 100 scientific papers. His current focus is on BIM use for energy efficient building design and life cycle management. At present, he is operative and scientific manager of the European projects HESMOS, ISES and eeEmbedded.

Peter Katranuschkov, TU Dresden

Title: Using BIM for Energy Efficient Building Performance: Are We There Yet?

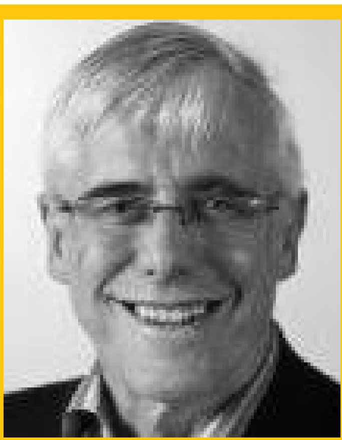
Main content:

The growing use of BIM-based working in the last years and the related needs for BIM-based interoperability of specialised AEC tools in various construction subdomains showed that a global all-encompassing model for all data in a construction project is not a realistic target, and that BIM data typically have to be combined with many other kinds of construction related data to be efficiently applied in real practice.

This presentation examines the possible use of the standard BIM specification IFC (ISO 16739) for energy performance simulation and life cycle analysis in building design based on findings from the European projects HESMOS, ISES and eeEmbedded. Discussed will be modelling challenges in the domain, approaches to meet these challenges, gathered practical experience and encountered problems in BIM use from several performed pilot projects as well as various difficulties on the way towards successful BIM deployment in energy aware design and construction practice.

Main topics:

- BIM challenges in the energy domain
- BIM-based multi-model integration
- Design Templates
- BIM to Energy Simulation mapping
- Modelling Levels of Detail, Levels of Development and Levels of Approximation
- Practical experience and encountered problems from performed pilot studies



Chris Groome trained as an economist. He worked in marketing and later in strategic planning in several industries before engaging with the building and civil engineering industries, first as a government adviser and then as general secretary of buildingSMART. He is involved in government as an elected councillor. He has a passion for good architecture and infrastructure and wants to see the construction industry transformed before he retires.

Christopher Groome, Building Smart

Title: Key role of international standards and their delivery for BIM implementation

Main content:

As they increasingly serve an international market, designers, manufacturers, assemblers and operators of built facilities have been handicapped by a lack of international standards for the processes, products and data that they use. These standars are now being established. In turn the existence of standards requires rigorous compliance activity to ensure that the advertised adherence to standards is a reality. Finally the ability of the people in the industry to migrate successfully to new methods of working depends on a local environment in which education, contracts, insurance and culture support a more co-operative style of working. BuildingSMART is tackling all these areas through its standards, compliance and chapter programmes. The speaker will set ut how it is reorganising to support BIM implementation across the world.

Main topics:

- Standardisation Benefits
- Operating Vision and Principles
- Standards programme
- Compliance Programme
- Chapter Programme

Development of BIM models in Portugal: Standardization of objects
F. Salvado, M.J. Falcão Silva, P. Couto, A. Vale e Azevedo
Portugal
Laboratório Nacional de Engenharia Civil

Restructuring Internal Roles With BIM Implementation
André Monteiro, João Lima, João Poças Martins
Portugal
bimTEC, FEUP

Building product manufacturers integration in the BIM process
António Frade Pina
Portugal
concepsysBIM

3D BIM TOOLS IN VIRTUAL CONSTRUCTION II REVIEW
Arnaldo Landivar Taborga and Regner Baek
Denmark
VIA University College

BIM Execution Plan Strategy for Collaborative Project Implementation
Bruno Caires; José Carlos Lino; Miguel Azenha
Portugal
NEWTON – Engineering Consultants, University of Minho

ProjetoBIM @ FAUP: New ways of thinking architecture at Oporto architecture school by the introduction of BIM methodology in teaching curriculum
Carlos Nuno Lacerda Lopes, Vanessa Tavares
Portugal
University of Porto, CEAU - CIAMH

BIMAppBuilder: A Framework Wrapping Selected BIM Functionality for Facility Management Applications
Chia-Ying Lin and Chien-Cheng Chou
Taiwan
National Central University

Are We Ready For BIM?
Emrah Türkyilmaz
Turkey
Istanbul Kültür University

The Future of BIM- the Merge of BIM & Project Management
Galina Kaloyanova
United Kingdom
BIM Angels

Construction Data Mining - The reuse of BIM Information in decision-making
Joana Coutinho; António Ruivo Meireles
Portugal
ndBIM Virtual Building

3. Conference Proceedings

Methodology for quality control of BIM models for 4D and 5D analysis
Nuno Miguel Gonçalves Russell Sampaio, João Pedro Couto, António Ruivo Meireles
Portugal
University of Minho, University of Minho, ndBIM Virtual Building

Using BIM for Energy Performance Simulation: Are We There Yet?
Dr. Peter Katranuschkov
Germany
TU Dresden

Improving MEP planning using BIM tools
Ricardo Daniel Fernandes Otero, João Pedro Couto, Francisco Reis
Portugal
University of Minho, University of Minho, EFACEC

BIM RESEARCH IN THE LAST DECADE
Ruben Santos, António Aguiar Costa
Portugal
Instituto Superior Técnico, Universidade de Lisboa

An application of CIM Models in Urban design and Land management: the case of Lisbon city
Sónia ILDEFONSO; Ana Paula FALCÃO; Helena RUA
Portugal
Instituto Superior Técnico, Universidade de Lisboa

Building Information Models for Architectural Design: an intuitive design methodology
Vasco Pereira; Alexandra Paio
Portugal
ISCTE- University Institute of Lisbon, ISTAR- Information Sciences, Technologies and Architecture Research Center and Vitruvius FabLab-IUL

Exploring Advantages and Challenges of Adaptation and Implementation of BIM in Project Life Cycle
Saeed Talebi
United Kingdom
University of Salford

Rethinking the Project Development Process through Use of BIM
Vimal Chaturvedi and Saeed Talebi
Unite Kingdom
University of Salford

Getting Started in BIM
Nick Allen
Unite Kingdom
Metz Architects

BIM Implementation for SMEs in the UK
Marina Machado, Jason Underwood and Andrew Fleming
United Kingdom
University of Salford

Information Handover Using BIM to Support Safe Facility Management Processes: Current Challenges
Eric M. Wetzel, Walid Y. Thabet and Buddy Cleveland
USA
Virginia Tech, 2Consultant

Development of BIM models in Portugal: Standardization of objects

F. Salvado, M.J. Falcão Silva, P. Couto, A. Vale e Azevedo
Laboratório Nacional de Engenharia Civil

1. Introduction

The management of information systems contributes to the economic development of the construction sector by organizing and structuring technical and economic information. It is proposed how BIM (Building Information Modelling) and a Portuguese information system - ProNIC (abbreviation for Protocol for the Standardization of Construction Technical Information) may be interconnected. The scope of this information transmission in construction sector is a step to solve several problems that have been identified in conception of BIM models.

2. Framework

ProNIC is a research project developed by developed by a consortium of three Portuguese research, development and innovation institutes (which integrate LNEC - National Laboratory for Civil Engineering).

The main purpose is to develop an information management system to support the construction industry that allows the simplification of proceedings related to contracts and make available both technical and economic information in a structured and standardized way [1,2].

ProNIC intends to be a system adapted to the Portuguese reality and the current practices, following the assumptions of the international standards. Given the scope of the subject, the goals are necessarily achieved through a gradual process of adaptation and transformation of information, followed by tests, corrections and validations.

In his base, ProNIC is a breakdown structure, commonly referred in English literature as Work Breakdown Structure (WBS). This structure may be more or less detailed in terms of associations or links established and dependent of the detailed degree desired. Contrarily to what occurs in other systems, ProNIC WBS, being the basis of all information produced, has been the object of a structured and comprehensive development in order to achieve a higher degree of detail. The task of defining the structure desegregation has been one of the main works.

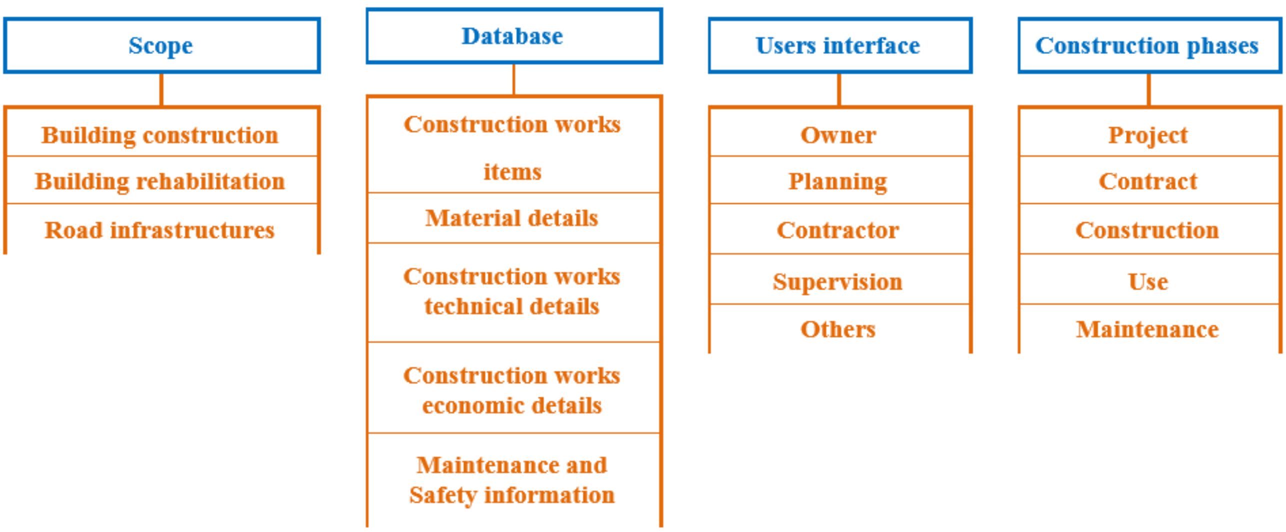


Figure 1 – ProNIC details

The ProNIC work classification criterion presents a division by chapters, subchapters and articles assigned to a particular code (the same code is always assigned to the same construction work). An article presents the description of the construction work, which will be edited and after integrated on the Work and Quantities Statement. After the definition of an article the designer can perform the measurements. The cost database philosophy is in accordance with the principles of cost and income data sheets developed by LNEC.

Linked with the article there are files with work and material technical specifications. These files are individual and seek the principle that each type of work has a description of how it is performed (a work specification file), and files with specifications for each different used material.

ProNIC comprehend the entire construction life cycle. From above, it is verifiable that it serves first the designer and

the work owner needs, mainly during the construction design and procurement. However, its structure contains features

that are transversal to all the constructive process, as the work contract process (designer and contractor/sub- contractors), construction (contractor and technical supervision) and use (maintenance provisions). It is expected that, in Portugal, ProNIC will be mandatory for use in public works process.

3. Standarized Information in BIM Objects

BIM methodology presents, as main asset, the possibility of an accurate representation of the objects geometry of a construction, together with the integration of information and organized data in several dimensions [3,4,5,6,7].

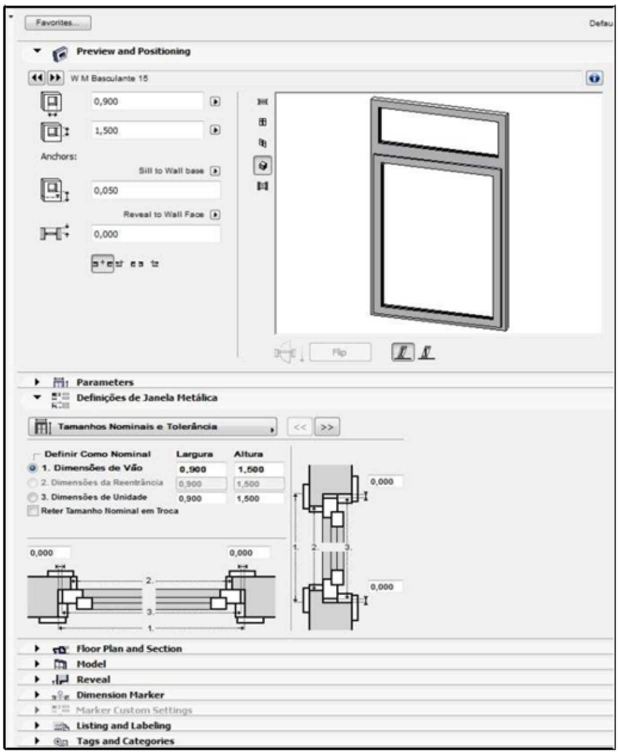
The constructive process starts from the owner idea of developing a project. This process gains information in different stages, information that is added to the process. The combination of documents, from drawings, images or written elements need to be defined during the design. The structural and data standardization of the attached documents has several advantages for the management of the different actors, both in terms of achievement, but also in view of a broad range of achievements that are developed by a given actors. In terms of construction sector assessment, it's possible to collect the data that will "feed" on the performance indicators.

In this aspect, ProNIC is well developed, because it incorporates technical content and items in different documents with details about work execution, materials and costs, associated to each construction work. This information is standardized and in accordance with the engineering projects under applicable European Standard. It also includes informatics applications of different interface modules with different users allowing them to work in a collaborative environment.

These contents intend to reflect the most recent information of the European and National standards and technical applicable references. From the described, it is not difficult to understand the amount of information present in ProNIC and its articulation on the creation of a construction design. The repetition of the described procedure for all the works allows the generation of the written specification required. The work and quantities statement is another document produced as the detailed measurements and estimated budget.

From a technological point of view it is possible, with greater or lesser difficulty, to establish a connection between BIM methodology and ProNIC with the aim to produce beneficial mutual results thus enabling time savings and improvement in quality and compatibility of the final product. As an illustrative example, a BIM object is presented, designed in appropriate software, for an exterior window (left side - Figure 2). In ProNIC, the same exterior window, define an article with technical and economic information associated (right side – Figure 2).

BIM OBJECT ← **PRONIC INFORMATION**



1. Technical information:

   Material characteristics:
   - Type of material
   - Type of coating
   - Anodizing thickness

   Mechanical and functional characteristics:
   - Deformation class
   - Pressure class
   - Water tightness class
   - Energy impact class
   - Safety device
   - Sound insulation
   - Heat transmission coefficient
   - Sun factor
   - Light transmission
   - Air permeability class
   - Maneuver force class
   - Torsion resistance class
   - Mechanical durability class

2. Economic information
   - Unit cost
   - Resources cost
   - Labor cost

Figure 2 – ProNIC information to integrate a BIM object

To define a BIM object, each user must fill the technical and economic characteristics (right side – Figure 2) according with the results of laboratory tests.

It is essential, to establish strategies and identify challenges and steps to be taken in order to proceed to this integration.

A proposed methodology to realize the link between the technical contents of ProNIC and the objects of the BIM model is following presented:

1. Defining normalized procedures for the parameterization of BIM models and the type of information and level of detail in each step of construction process;

2. Implementing and defining the configuration of fundamental principles in order to obtain an evident, objective and concise information in accordance with applicable law and Portuguese reality;

3. Making correspondence between the parameterization of BIM methodology and the ProNIC classification of construction articles;

4. Associating each parameterized building BIM object with a few ProNIC articles. The engineering projects are the same in ProNIC and BIM methodology and are in accordance with the provisions of Portaria n. º 701- H/2008 (in the case of Portuguese law, transposed from the European Standards) [8,9];

5. Integrating the technical information available on ProNIC in each parameterized BIM object;

6. Organizing ProNIC articles associated to BIM objects with the aim to prepare the technical documents, measurement details, work quantities and budget estimates. ProNIC makes a direct connection of project information to planning and construction management modules.

4. Final Remarks

The ideal integration scenario, for the information system in the construction industry, is one that all actors are interconnected and work in a collaborative mode, throughout all phases of the building life cycle and all tools communicate in order to produce the desired results.

Integration of BIM models with other tools to support the construction process is essential to develop and diffuse their utilization. For this purpose, a research study is being development in LNEC for different BIM objects related to the architecture and structure projects of the building elements.

The example presented in this paper, though still at a preliminary stage, aims to integrate the technical and economic information already normalized for several BIM objects.

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Are We Ready For BIM?

Emrah Türkyilmaz
Istanbul Kültür University

1. Introduction

BIM for Building Information Modelling is a concept appeared in the middle of 90's. The idea of BIM is to integrate all building information in one only concepts. Although the name originally found by Autodesk, it was used by other software developers such as ArchiCAD and Allplan. It is widely expected that Building Information Modeling (BIM) will lead to changes in the future of professionals in the Architecture, Engineering and Construction (AEC) sector. Although there are enough discussion on the advantages and the usage areas of BIM, problems for BIM practice still continue. Problems for practice should be discussed at three different levels:

- Architecture, Construction and Engineering Sector
- Education
- BIM software

2. Problems for BIM Practice

2.1 Architecture, Engineering and Construction Sector: The approaches of employers and the conditions of workers

- It is difficult to find qualified workers working for BIM software
- Experienced workers prefer to continue working in conventional systems. Therefore, there is an integration problem between experienced workers and qualified BIM users.
- It takes time to train the existing staff
- Change in software is very expensive and imposes additional costs for AEC firms. Therefore medium and small scale businesses could not meet these costs alone and they are out of BIM sector indispensably
- Due to pricing policies of software, it is adhered to a single software manufacturer. The technological features of software producing by this company affect BIM works.

2.2 Education: The conditions of academicians and the attitudes of students

- Architectural curriculum does not contain efficient BIM education,
- Academicians are less interested in BIM topic and mostly they prefer to use conventional methods in education,
- Students are not encouraged to use BIM throughout the education period. Therefore, they cannot develop themselves about BIM,
- There are problems to do internships in BIM companies.

2.3 BIM software: The qualification/sufficiency of software and the view of distributors

- Interoperability of BIM software is still insufficient,
- Although IFC data exchange standard is an international open source, BIM software do not work in accordance with IFC,
- Software are being updated very often so there are compatibility problems between BIM files,
- Software remains weak particularly in producing details,
- It is necessary to make expensive hardware investments in order to work BIM software properly. To see an entire structure virtually is still not possible even with expensive hardware.

3. Conclusions

Although there is a demand for more qualified workers in AEC sector, it should not be realized the usage of BIM software in an efficient manner in case of not doing any modernization of working systems of firms. In addition, major design firms should have an entrepreneurial behavior for working with BIM and they should have willingness to use BIM software. Software companies should also increase studies to develop their products more useful and more understandable.

More BIM courses such as, technology course, design studio, collaborative studios. should be added architectural curriculum. Beside students should be encouraged working with BIM. The use of BIM in architectural education is still limited with the design process. It is not possible to say that the use of BIM in environmental analysis, building construction and building management is efficient. By using BIM software accurately, it is possible to solve frequently encountered problems of design process related with transition from conceptual design to application such as wrong calculated dimensions, undefined basic structural elements, undefined mechanical systems etc.

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BIM at Somague – Toward the effective utilization of Building Information Modeling

Joana Melo; Pedro Costa; Bruno Caires;
José Carlos Lino; Nuno Lacerda
Somague Engineering; BIMMS

1. Introduction

BIM is being increasingly acknowledged as having the transformative potential to create a new paradigm within the architecture, engineering and construction (AEC) industry [1]. This innovative methodology is able to provide a holistic and more cooperative vision of the project, making explicit the interdependencies that prevail between the various actors, by technologically coupling their designs, enabling the virtual construction and management of the building project [2, 3].

In the builder's perspective, BIM can be put in terms of its technical aspects as a management or documentation tool, serving as a project instrument to support the decision making and risk assessment throughout the construction and operation phases. The easy assessment and management of all information, including the clear visualization of the solutions are the key leverages that permit to forecast and anticipate potential incongruities inherent to a building process. Ultimately, by implementing this innovative work methodology the materialized digital model is the ultimate database, supplying the correct information at the right time to sustain the definition and efficient evaluation of scenarios [4].

Currently, BIM is hastily disseminating in a global context, where various public entities and private organizations are setting, as a requirement, the implementation of this work methodology for their building designs. Furthermore, various governments have traced strategic approaches to support a sustainable implementation of BIM in their construction industry, acknowledging its importance in their overall economic performance outcome. Companies of the AEC industry are adapting to this new reality in order to maintain or increase their international competitiveness and productivity/quality edge in relation to their market competitors [1].

Acknowledging these productivity advantages and commercial procurement leverages, Somague is currently keen to develop a universal strategic BIM implementation plan that embraces all fields of its activity. For the development of this operation, a strategic partnership with experts in BIM consulting and integrated project, Building Information and Management Solutions (BIMMS) was established, with the intent to share and develop knowledge in the fields of BIM strategy implementation, BIM advanced construction management methods, integrated disciplinary modeling strategies and other management solutions.

This work summarizes Somague´s BIM implementation roadmap that has been carried out, by discussing the approach undertaken and analyzing some practical experiences of BIM-related implementation efforts. Additionally, the main results achieved with the partnership with BIMMS are highlighted. To conclude, future aspirations for the utilization of BIM at Somague are shared.

2. OUR ROADMAP UP TO NOW

With an experience of more than 65 years, possessing expertise in the fields of Hydraulic, Marine, Rail, Transportation Infrastructures, Industrial and Building Construction, Somague has leaned on its expertise and has always been aware of the market´s trends and new technologies (being itself, at several occasions, the author of various research and development (R&D) projects) to achieve its objectives.

Nonetheless, because Somague doesn´t just want to construct the future, but wants to construct it efficiently, and has always seen each project as a challenge, it has been felt that the use of BIM in individual cases of implementation does not meet the expectancies. So, after having experienced several key phases of awareness, such as the necessity, the consciousness and the advantages of communication associated with productivity, came the requirement of developing an integrated, cemented and sustainable implementation strategy plan of BIM within Somague´s work process. The following summary outlines the experiences verified in each phase mentioned above:

2.1 Necessity and Consciousness

The Casa da Música of Oporto (2001), being such a unique, sophisticated and iconic construction imposed just like any work of art challenges associated to its interpretation, being evident the necessity of employing other means of work to support the understanding of the building´s design. Only by developing the 3D model of the building was it possible for stakeholders of the construction team to overcome the barriers of misinterpretation of the project and be able to conjugate the architectural and structural design (see figure 1). Additionally, with the virtual model it was possible to identify faults of the project, prevent errors of construction and overcome linguistic barriers at the construction site by using the 3D digital model as a communication tool.

Either on a maritime work underwater project (see figure 2) the necessity of pre-visualization by divers of the work they would found underwater, was essential to accomplish the work on time and with the quality needed.

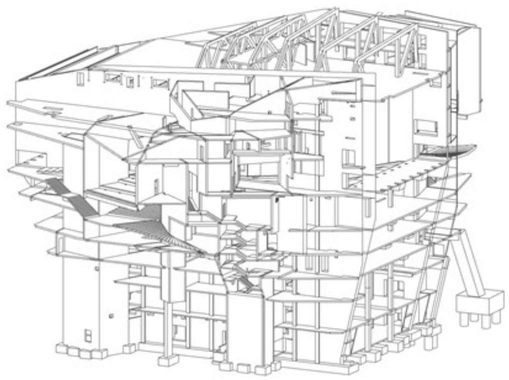

Figure 1 – Casa da Musica of Oporto, 3D digital model

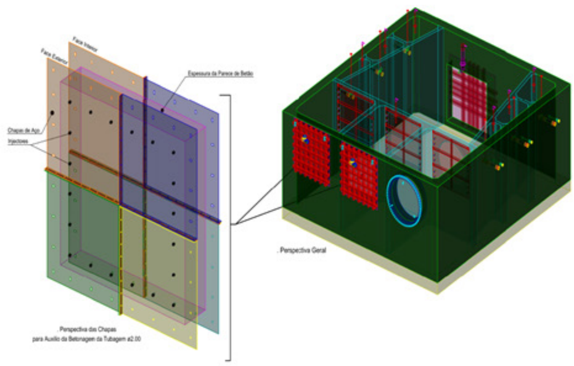

Figure 2 - Maritime work underwater project

2.2 Communication associated with productivity

The communication among the stakeholders of the construction site can be the biggest barrier or greatest ally in the progression of the work. By implementing a BIM-related approach in a current dam project (see figures 3 and 4), where the dam was modeled with all organs and its establishment within the actual surroundings and existing construction works, provided a base for all the involved entities of the construction to discuss, foresee and develop a more rigorous preparation plan. The current results appoint to the quicker procedures to extract detailed quantities and documentation, detection of inconsistencies and the incorporation of the updates of the engineering designs.

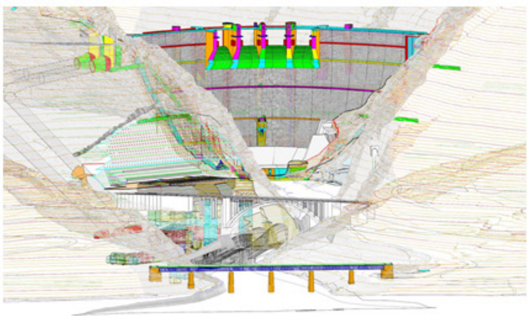

Figure 3 – Foz Tua dam project, surroundings.

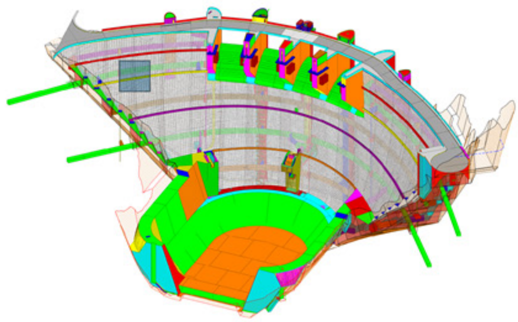

Figure 4 – Foz Tua dam project, overall view

2.3 The Practical Implementation of the BIM methodology – Partnership with BIMMS

All past BIM-related experiences that Somague established were dispersed in time and space, never verifying a sustainable initiative to develop a strategic implementation plan for BIM, despite their positive outcomes. Furthermore, in these projects the application of the BIM methodology was applied at an elementary level, distant from main potentialities of BIM. With this, Somague intends that it has reached the adequate time to invest and develop sustainable implementation plan for BIM that is universal to all its activities. To this extend, Somague resorted to the consulting services of BIMMS, with the intent to beneficiate from its specialized expertise in the areas of practical BIM strategy implementation in projects and firms, BIM modelling approaches, BIM content management, BIM coordination activities (team and model management), technology strategy, quality model assurance techniques, construction support and other management solutions (such as, BIM advanced construction management methods and facility management).

Various pilot-projects are being undertaken within Somague, with the collaboration of BIMMS, with the intent to create internal processes and be divulgated and represented to the remaining organization of Somague for future dissemination of the BIM methodology to all lines of work.

3. FUTURE DIRECTIONS

With the sustainable implementation of BIM within the work processes of Somague, it is intended that it will contribute to the expansion of BIM methodology in other business areas, particularly in operation and maintenance of structures and infrastructures, including the development of advanced construction management techniques.

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Implementing BIM: Roadmap proposal for Portugal

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1. Introduction

Building Information Modeling (BIM) is a technology, and not a specific program, that offers an integrated platform to improve design, increase the speed of delivery for design and construction, and provide a flow of information without breaks. It is a process involving generation and management of digital representations of physical and functional characteristics of places, which can be exchanged or networked to support decision-making.

The use of BIM software goes beyond the planning and design phase of the project, being extended throughout the building life cycle, supporting processes including cost management, construction management, project management, facility operation and maintenance of diverse infrastructures (water, wastewater, electricity, gas, waste, roads, bridges, ports, houses, apartments, schools, hospitals, shops, offices, factories, warehouses, prisons, etc.) [1].

2. INTERNATIONAL BIM DEVELOPMENTS

The adoption of BIM has already been a global trend (Figure 1), being presented in the following the main international BIM developments [1][2][3][4][5][6]:

1. Australia – Not mandatory for projects, nevertheless was used for the project of Sydney Opera House;

2. Brasil - Began to be implemented in 2006 in some private initiatives. In 2010 ABNT / 134 EEC Special Commission to Study the implementation was created. In 2011 BIM was widespread to public initiatives;

3. Canada - Founded by the end of 2008, the Canada BIM Council for support the adoption of standardizes models in architecture, engineering and construction, to manage national-wide implementation and introduce good practices and standards. Requires the use of BIM in public construction projects;

4. Denmark – BIM began to be used in projects during 2001. Its use became mandatory in Federal projects during 2007;

5. Finland - Requires IFC/BIM in its projects (public buildings) and intends to have integrated model-based operation in future since 2007. Mandatory for infrastructures project since 2014;

6. Hong Kong - The Hong Kong Institute of Building Information Modelling (HKIBIM) was established in 2009 and the Hong Kong Housing Authority set a target of full BIM implementation in 2014/2015;

7. India - In India BIM is also known as VDC: Virtual Design and Construction. It has many qualified, trained and experienced BIM professionals who are implementing this technology in Indian construction projects and also assisting teams in the USA, Australia, UK, Middle East, Singapore and North Africa to design and deliver construction projects using BIM;

8. Iran - The Iran Building Information Modeling Association (IBIMA), founded in 2012, shares knowledge resources to support construction engineering management decision-making;

9. Lithuania - Is moving towards adoption of BIM infrastructure by founding a public body "Skaitmeninė statyba. BIM (Building Information Modelling), Industry Foundation Classes (IFC) and National Construction Classification will shortly be adopted as standards;

10. Mainland China –BIM has been included as part of the National 12thFive Year Plan (2011 – 2015) and is formulating a BIM framework. It was created a partnership between Academy of Building Research Technology and Autodesk for BIM models;

11. Norway - BIM has been used increasingly since 2000. Several large public clients require use of BIM in open formats (IFC) in most or all of their projects. National BIM development is centered on the local organization, buildingSMART Norway which represents 25% of the Norwegian construction industry. Requires IFC/BIM for new buildings since 2010;

12. Singapore - Determined national-wide implementation roadmap in 2011. BIM as part of public sector building project procurement (2012). BIM introduced for architectural submission (2013), structural and M&E submissions (2014). Requires mandatory use of BIM from 2015 onwards

13. South Korea - In the late 2000s the Korean industry paid attention to BIM. It has been spread very rapidly. Since 2010, the Korean government has been gradually increasing the scope of BIM-mandated projects. In 2012 was published a detailed report on the status of BIM adoption and implementation;

14. Sweden – BIM important in infrastructures project. Creation of openBIM with 95 partners

15. The Nederlands - By the end of 2011, Rijksgebouwendienst, the agency within the Dutch Government that manages government buildings, introduced the RGD BIMnorm which was updated on July 2012. It is mandatory for Public works > 10M€;

16. United Kingdom - In 2011 the UK government published its BIM strategy. Government requires mandatory use of BIM in public sector (£5 million) from 2016 onwards. Their target is to become BIM leader in European region;

17. USA - The General Services Administration requires mandatory BIM submission for government projects since 2008. They are experts in using BIM and are leading BIM practice;

18. Other Countries - Some European countries (France, Switzerland, …) require the use of BIM in public construction projects, and, some of them set up agencies to manage national-wide implementation and introduced good practices and standards.

Figure 1 – Global perspective of BIM implementation throughout the world

3. ROADMAP PROPOSAL FOR PORTUGAL

BIM is a relatively new technology in an industry typically slow to adopt changes, especially in Portugal. Compared with international practice of BIM with respect to planning, adoption, technology and performance, Portugal is lagging behind majority of developed countries. Yet many early adopters are confident that BIM will grow to play an even more crucial role in building documentation.

Following the example of other countries, the spread of BIM through Portuguese reality will bring in a close future [1]: i) improved visualization, ii) improved productivity due to easy retrieval of information, iii) increased coordination of construction documents, iv) embedding and linking of vital information such as vendors for specific materials, location of details and quantities required for estimation and tendering, v) increased speed of delivery, vi) reduced costs, and, last but not least, vii) approach from what is happening in the so called "most developed countries" and consequently creating great potential for the development of the construction industry and related areas. However, there are challenges that must be overcome, such as: i) lack of demand for BIM, ii) entrenched in the current 2D drafting practices, iii) lack of ready pool of skilled BIM manpower, iv) additional resources needed to build BIM expertise [7]. Despite the challenges presented (Figure 2), is possible to identify strategies that allow wide spreading BIM use in Portuguese Construction Industry in the next years.

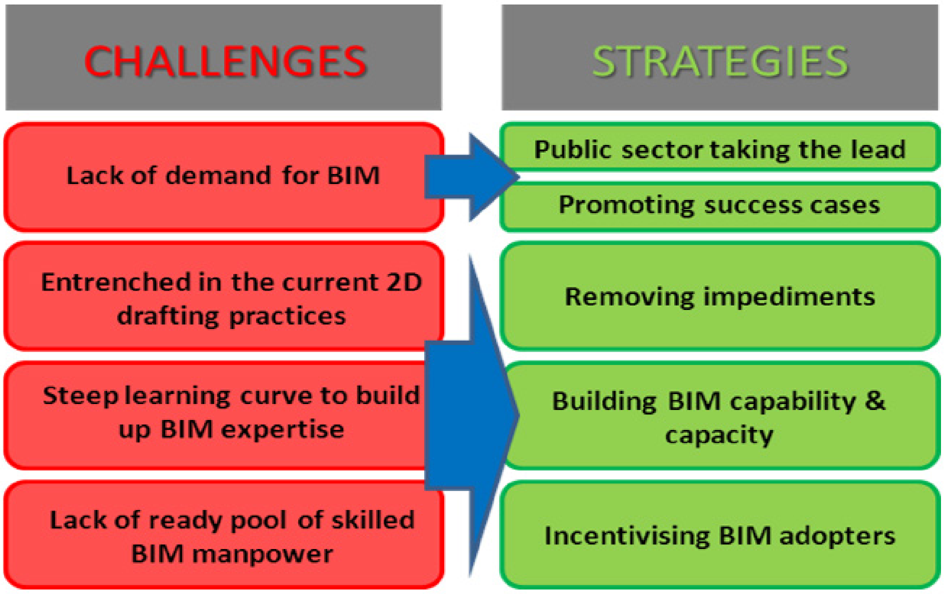

Figure 2 – Relation between challenges and strategies for wide implementation of BIM, adapted from [7]

Considering what has been presented in the previous paragraphs it seems that a possible roadmap proposal for a wide implementation of BIM to Portugal until 2020 will comprise the strategies previously mentioned (Figure 1) and the actions following described in Table 1.

STRATEGIES	ACTIONS	DATE
Public Sector taking the lead	Establish Center for Construction IT help key agencies and construction firms to kick start BIM	Year 1
	Work with key agencies on pilot projects	Year 2
	Work with key to prepare consultants and contractors who undertake the public sector projects to be BIM ready	Year 3
	Mandatory Architecture BIM e-submissions for all new building projects > 20000m^2	Year 4
	Mandatory Engineering BIM e-submissions for all new building projects > 20000m^2	Year 5
	Mandatory Engineering BIM e-submissions for all new building projects > 5000m^2	Year 6

Promoting success cases	BIM Competitions	>Year 2
Removing impediments	Growth of BIM communities	Year 1 to Year 2
	National BIM leadership through the BIM Steering Committee • Advise on effective implementation of BIM: o BIM Guide workgroup o Legal & contractual workgroup o Inter-disciplinary workgroups • Develop and use local BIM standards	Year 4
Building BIM capability & capacity	Equip the future generations of Architects, Engineers and Construction Professionals • Awareness Seminars • BIM Curriculum in Academic Institutions • Graduation workshops • Student's expert program • Internship program • BIM center of excellence • Applied BIM R&D	Year 1 to Year 6
Incentivizing BIM adopters	Construction Productivity & Capability Fund – BIM Fund • Firm level scheme • Project Collaboration Scheme	Year 5 to Year 6

Table 1

4. FINAL REMARKS

In Portugal, the basis for an extended BIM adoption, according to the general opinion, must be the achievement of national BIM standards, being also necessary to equate the mandatory adoption of this methodology, similar to that of trend is seen in other countries. Interoperability, standardization of procedures, the involvement of the various actors of the construction process, the creation of a collaborative network are critical aspects repeatedly emphasized in Portugal as fundamental to optimize and disseminate the implementation of BIM.

Portuguese construction industry is strongly encouraged to take leap to catch up the fast pace of the global adoption of BIM so as to maintain the competitiveness of Portuguese Architecture, Engineering and Construction (AEC) services in the region and even in the world. Considering the increasing use of management information systems in construction and the perspective of its obligation imposed by the Government, it is expected that the use of BIM in Portugal will also be mandatory in public works process.

The roadmap proposal to Portugal aims to realize the vision of a highly integrated and technologically advanced construction sector that will be led by progressive firms and supported by a skilled and competent workforce in 2020.

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Automated assessment of value in Brazilian's housing design

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1. Introduction

This paper proposes a design method that incorporates desired values of the cost estimate, within an approach to target costing and integrated with Building Information Modelling (BIM). This design method incorporates assessment mechanisms associated with the desired cost during the design process for Social Interest Housing (SIH), developed under the aegis of the housing program, developed by the Brazilian federal government called Minha Casa Minha Vida (MCMV). Research shows that there is a real possibility of inclusion of methodological tools of design, allowing assessment of desired values in real time during the design actions. These values can contribute to the redirection of a design proposition, enabling designers' decisions are taken more clearly given to the wishes of the residents, without disregarding the cost, which is essential for the viability of a project with these characteristics.

The first stage of this work consisted of a critical analysis of architectural production and construction technologies for SIH buildings, developed over the last five years in the Metropolitan Region of Recife/Brazil (RMR) and funded by MCMV, in the segment of the population that has labor income between 4 and 10 minimum wages. For this, a documentary research was carried out.

The next step is to develop a design method, supported by a computational BIM authoring tool (customized) for the development of architectural designs of SIH. This method aims to incorporate the analysis of costs and value perceived by the customer, still in the preliminary study. Data from the documentary research were essential to define the mode of operation of the variable and entering information into templates to be used by designers.

2. Valor Desejado da Habitação de Interesse Social no Brasil

One of the approaches most commonly discussed in social housing in Brazil comes to the cost of production and maintenance of SIH. This almost does not consider the value associated with the cost of housing. Approaches that consider the value are generally empirical and contribute little to the quality of the solution, which is difficult to be implemented in design projects. On the other hand, authors such as [1] shows that a values-based approach, from the theory of hierarchy of needs, should be a key element in any building project.

The concept of value for [2] is intrinsically related to satisfaction for the customer. The author infers that the judgment of satisfaction is about the influence perceived by the customer, both in pre-purchase situation (desired value) and in the post-purchase (amount received) value. The amount received, in turn, is related to the tradeoff between the benefits received for the purchase of the product or service, and sacrifices perceived when confronted with the price of these.

From analyzes of studies that evaluate the desired value of SIH in Brazil, was possible to identify the most relevant values and could be quantified and put into design processes of SIH. These activities include: [3] and [4]. These served as references in the definition of desired values used in this research.

From the analysis of the values considered important in the two studies mentioned above and based on the values that could be better quantified and transformed into design data, was reached to the set of Values Desired to be considered in this research. Based on these values, we sought to identify categories of cost that could be related to the Desired Values. Among the identified costs are: Absolute Cost and Relative Cost. The Absolute Cost refers to a cost that is common to all housing units, given in terms of the characteristic of the project (eg, cost of the condo).

The Relative Cost refers to the cost added to the apartment due to specific characteristics. This can vary depending on the location and disposition of the housing unit (e.g., location of facade from the North).

From the considerations presented above is briefly reached a relation of Costs of Desired Values (CDV) and the impacts of these in the Final Cost of the Building (FCB). The FCB is the sum of Total Construction Cost (TCC) of the building + CDV.

To obtain the CDV parameters were used as data obtained in documentary research, and information of the brochures and specifications of MCMV. For the TCC were taken into consideration, construction technologies used. The technologies identified in the case studies were: concrete walls (in situ), reinforced concrete structure with column and beam and structural masonry with concrete block. For each of these technology were studied these components that had the largest weight in the price of construction.

For the search results were considered satisfactory as would be necessary for CDV and TCC were aggregated to the tools used by designers during the design process. So that it was possible that the values could be measured automatically by virtue of design decisions.

In the final stage, this research proposed a methodological process that allows that CDV is already obtained in the preliminary design study phase. The idea is that CDV be added in templates BIM authoring software. These templates should be used by designers already during the early stages of the design process. These templates also incorporate information about construction technologies, components and dimensional standards used in this type of project.

Is important to say that, the CDV need to be transformed into monetary values and need to be "hanging" in the templates, so that, they can be rescued, according to the feature of the project. For the analysis of a specific design proposition the model should provide quantitative useful for the creation of CDV and TCC.

Regarding the insertion of data to obtain the values sought to minimize the work of designers. The goal was that they had the least amount of work in order to compromising to a minimum the design process. To do this, has limited inserting the value data to a single building system: Zone (Zones, according to [5], are spatial units of the project).

From the data obtained directly from the Zones it is possible to extract the values of the main quantitative included in the survey. The settings on the type of information present in the Zones were also incorporated in the project templates within a BIM authoring software (ArchiCAD from Graphisoft). These templates were created (automatic) tables with quantitative.

The TCC is also being obtained automatically, from the definition of those families of components that have the greatest impact on the cost of the project. These families are aggregated to templates, which, in turn, reproduce the main building technologies used in this type of building.

At the end of an architectural solution, the designer must export the table of quantitative (is ready - in the template) for The Microsoft Excel. In the latter software, a Macro was created with information about indexes and formulas for calculation of results. So, when you open the Macro tables exported from ArchiCAD is possible to obtain, in an automated manner, the results of CDV and TCC.

3. RESULTS AND DISCUSSION

What is expected, finally, is that at the end of the development of an architectural solution of SIH, already in the preliminary study, it is possible to obtain the CDV and the TCC of the proposed architectural solution. Thus, it will be easy and quick to identify the impacts of spatial changes in CDV and TCC. It is believed that by obtaining these impacts, will be possible that designers and builders to assess, much more accurately, the costs of architectural decisions on designs of SIH and impacts of these costs on the FCB.

4. CONCLUSIONS

What can be concluded with this research, albeit still very preliminary results, is that there is a real possibility of inclusion of methodological tools of design, allowing assessment of Desired Values, in real time, during the design actions. These values can contribute to the redirection of the design propositions. These may contribute to the decisions of the designers are taken according to the real wishes of the inhabitants, without, however, disregarding the costs of construction, which are essential for the viability of a venture of this kind.

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An application of CIM Models in Urban design and Land management: the case of Lisbon city

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1. Introduction and Background

City Information Models (CIM) combine the traditional capabilities of a Geographic Information Systems (GIS) with the capacities of a Building Information Model (BIM) allowing a qualitatively and quantitatively space description.

In this communication, we highlight the importance of CIM models in land management, using procedural modelling techniques based on Computer generated architecture (CGA) shape grammar, by developing a methodology to automatically evaluate the municipality detailed plan fulfilment, such as the maximum building height allowed.

The study case is Lisbon downtown, however the CIM model was built for a larger (3,670 x 2,300 m) area, comprising 11,602 buildings. The software used in the model construction and spatial analysis was CityEngine (CE), provided by ESRI-Portugal.

2. Data description and methodology

BThe study case is Lisbon downtown (Figure 1) corresponding to an area that is protected by a heritage plan, namely Plano de Pormenor de Salvaguarda da Baixa Pombalina (PPSBP), that imposes restrictions on construction and occupation, such as the number of floors, the maximum building height and footprint area.

The data available for this work was: orthophotomap at 1/1000 scale, contours and height points, building footprints and attributes such as the number of floors above ground and underground.

The methodology followed in this work to build the CIM model was based on these steps:

i) Combining height data to generate a digital elevation model, onto which the orthophotomap and building footprints were projected;

ii) Generating the 3D buildings/blocks by applying basic authored shape rules (Andrade et al., 2012);

iii) Enhancing the model by adding textures, constructive details and specifications. Different levels of detail – LOD (Chen, 2011) were considered: for the Lisbon downtown attributes such as the number of floors above and below the ground surface, the façades orientation, type and colour (LOD2 and 3); for the surrounding area only a volumetric representation was considered (LOD1).

Figure 1 – Perspective from Lisbon CIM model section (grey colour) and downtown (yellow)

In order to automatically analyse the fulfilment of the maximum building height set in the heritage protection plan, a new rule was produced to allow a visual inspection of the current situation (Fig. 2, yellow colour scenario for current situation and green colour scenario corresponding to the maximum height values, according PPSBP).

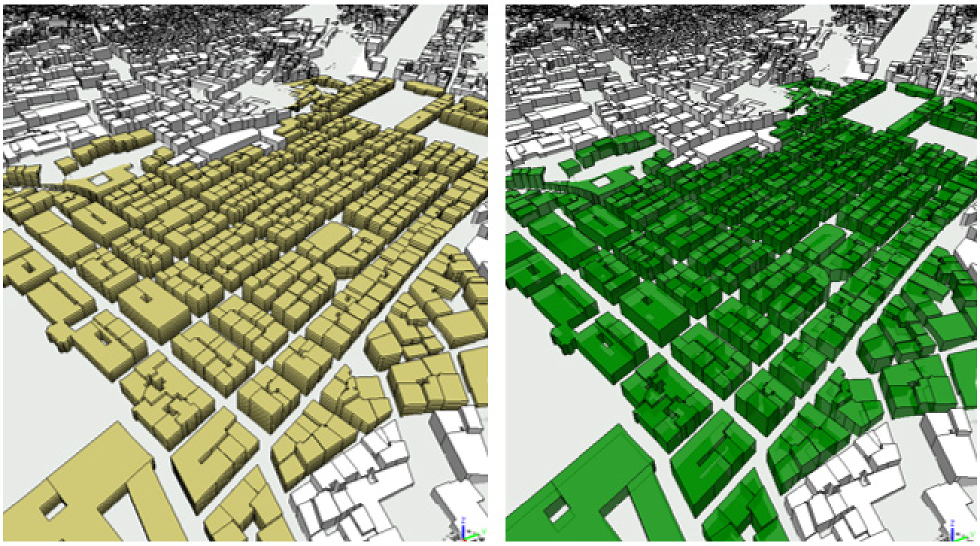

Figure 2 – Maximum building heights: a) current city; b) maximum heights [PPSBP]

3. Results and discussion

Figure 3 presents the differences between the allowed and the current building heights. This methodology of conformity analysis by visual inspection, between the proposed and the existing, can be extended to other parameters such as the maximum gross area or to automatically assess if new projects comply with the rules. In this last application the rule is prepared to quantify the differences between the proposed and the allowed.

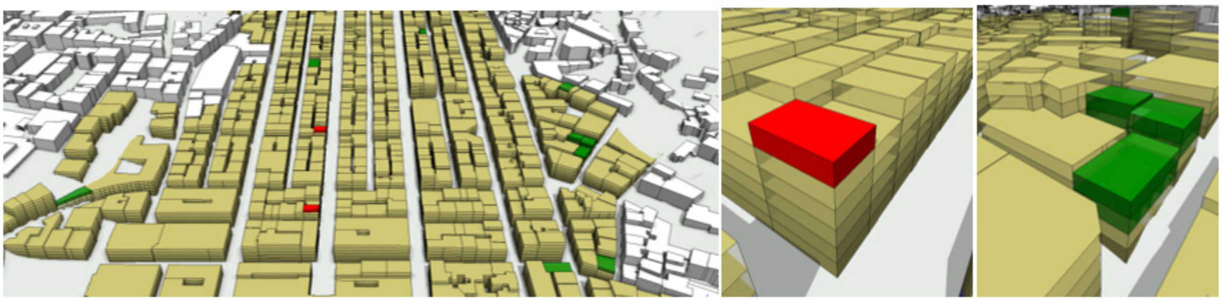

Figure 3 – Representation of the height differences (between the current situation and the height values presented in detailed plan) for Lisbon downtown PPSBP area (green: enlargement; and red: demolition)

4. Conclusions

The use of CIM models in land management is an opportunity; the use of tools to automatically evaluate the differences between the proposed and the allowed will save time and resources. The area selected for this study is not the most appropriate because it corresponds to a consolidated urban area and due to its high heritage value is not included in the municipality plans revision. Further developments to this work will include new rules to automatically evaluate parameters such as the building orientation and sun exposure.

5. Acknowledgments

The authors would like to thank the Geographic Information Department of Municipality of Lisbon, namely Architect Rui Ricardo, for all the support and geographic information data.

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BIM Implementation for SMEs in the UK

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1. Introduction

Small and Medium Enterprises (SME) are predominant on most economy structures, in fact, in the United Kingdom construction industry SMEs represent 99.7% of the whole industry [1]. To respond to the competitive pressures from low cost international nations, the increasing concerns with health and safety, and the sustainability agenda, the UK Government is encouraging innovation on SMEs [2, 3]. The focus tends to be more in product innovation rather than in process innovation, although several studies show that the use of business approaches such as process improvements and knowledge management can incrementally reduce costs and increase competiveness for SMEs [4, 5]. Moreover, Building Information Modelling (BIM) is one of the promising approaches to improve processes and efficiencies in the construction industry [6].

BIM is defined as an adjective or verb related to the generation of models that contain geometry and structured reliable information about a building during its life cycle [6]. Its adoption and awareness is growing in the UK construction sector: The National BIM Report Survey (2014) found that 95% of the practitioners are current using or believe that they will be using BIM within the next 5 years [7]. There is an influence of the "push-pull" Government Strategy for BIM, that will mandate the adoption of BIM in all centrally public procured projects from 2016, and a 'feeling' of BIM being a new standard for project information, which is transforming the construction industry landscape. Despite the growing uptake of BIM, there is still a lack of understanding about what a BIM implementation represents for a business and about the role of SMEs in the dissemination of BIM adoption in the UK.

This paper presents part of a BIM Implementation Project through a Knowledge Transfer Partnership (KTP) between the University of Salford and Links Project Management, a design-manufacture-fit-out company based in the UK. A KTP is a program partly funded by the UK Technology Strategic Board with the objective of supporting businesses that want to increment their performance and competitiveness with innovative solutions by accessing universities knowledge and expertise. The commercial driver for Links to engage with BIM are firstly to be aligned with the commercial demands for BIM by 2016 (as mandated by the UK Government Strategy); secondly, to streamline operations to increase effectiviness and profits.

Implementing innovation within SMEs is complex and a non-linear process, suffering from scarce resources, lack of skills and lack of systematic measurements, which can result in implementation failure and frustration for SME managers [5]. The aim of the KTP Project is to support the company in these areas and thereby increase the chances of success of the BIM Implementation.

The purpose of the paper is to inform both industry and academics about the methods and results achieved with the BIM Implementation in an SME by discussing the progress and results of the project to date.

2. Methodology

2.1 Case study

The research is based on a case study of a BIM Implementation within a SME – Links (around 40 people) - that provides full turnkey solutions for living environments for student accommodation and hotels across the UK, with a turnover of about £6million/year. The company offers a full fit out service of quality fittings and furnishing including design, manufacture, fitting and supply of goods into construction projects and refurbishment. The company operations is divided in 3 core areas: an office, a co-owned furniture factory and a permanent employed site team.

The project objective is to implement BIM within Links ensuring the company has the expertise needed to operate in a BIM environment from design to manufacture and installation, integrating the three core areas. The project duration is 30 months and it is divided in 5 stages: Stage 1: Establish and consolidate best practice knowledge in BIM; Stage 2: Detailed review and analysis of the organization's current situation; Stage 3: Develop BIM-based collaborative strategy; Stage 4: Pilot implementation of BIM-based collaborative strategy for DfMA; Stage 5: Project review, evaluation, and dissemination.

The first stage of the project, in informing the project going forward, has recently been completed through a review of literature of current BIM Implementation Projects in the UK, the UK Government BIM Strategy and BIM for Design for Manufacture and Assembly (DfMA). In addition, primary data has been collected from interviews with industry key players and members of the company along with company observations.

3. Results and findings so far in the project

3.1 Opportunities for BIM in SMEs

Stage 1 has clarified that the benefits of BIM are achieved according to the level of engagement of the company with BIM. To avoid a negative impact on the implementation, the organization should identify the areas where the return of investment in BIM is more likely to be achieved with less investment, and continue the implementation progressively. This study found that at Links a quick acceptance for culture changes and a positive response of BIM engagement exists; confirming that SMEs tend have flexible structures and respond rapidly to changes.

Large contractors are in the forefront of BIM in the UK. However, regardless of their importance, they are a minority of the industry in the UK, whereas SMEs constitute the majority part of the industry. Therefore, for large contractors to achieve high level of expertise in BIM the collaboration with SMEs sub-contractors and suppliers that have adopted BIM is crucial, particularly in achieving the mandate set by the UK Government. Thus, opportunities for SMEs with a satisfactory level of BIM expertise include possible commercial advantage when main contractors that are using BIM manage projects. More than just winning a single contract, SMEs could benefit of repeated business through establishing long-term relationship with their supply chain by the engagement of BIM.

A further opportunity is the development of new products and services related to BIM being commercialised in the national and international markets. While BIM transforms the way the industry works, new products and process are going to be demanded by the industry in fancitating the transformation, and SMEs can respond to this demand along with gaining competitive advantage.

3.2 Challenges for BIM in SMEs

Dealing with the resistance of people to change is one of the main challenges experienced on a BIM Implementation, irrespective of the company size or activity. Part of a BIM Implementation is to deal with skeptical people that do not fully understand or believe the benefits of BIM. This study is addressing this challenge by raising the awareness of BIM through presentations in assisting employees individually on practical experiences using the BIM Model.

SMEs report another challenges to implement BIM: costs of software and time for training. The company needs to find a financial benefit to investment in BIM. However, is not easy for all sub-contractors to value BIM.

SMEs sub-contractors also deal with the risk of not knowing in advance what information about the project will be shared with them. There is an intrinsic risk on the traditional procurement routes that inhibit collaboration and increase the risk for Tier 2 and Tier 3 companies. One main contractor interviewed suggests that Tier 2 and Tier 3 companies ask what information their client need and in which format as a starting point on the development of a strategy for BIM, reducing the risk of spending time and resources producing information that will not be necessary for their clients.

3.3 Business Process Analyses and Business Strategy

The most effective BIM implementation strategy must be aligned to the business strategy, based on a review of organization's business process and workflow, both internally and externally [8]. However, small companies tend not to have business processes formally documented and neither formal business strategy.

In the inexistence of a clear business' strategy, in the early stages of BIM Implementation, is necessary to clarify objectives for the BIM Implementation aligned of the direction for the future of the business, in order to avoid frustrations and failure of the project. For this reason, the academic team decided to support the development of a formal business strategy for Links, providing guidance with workshop sections.

Currently, existing business processes are being mapped in order to allow a better understanding of the company processes, procedures and information flow. The BIM Implementation is a trigger for the company to define standardised process, eliminate waste and duplications in the processes and establish a better operation flow.

4. Conclusions

This study has assessed the early stages of the BIM implementation case study of Links in the KTP Project, highlighting findings on challenges and opportunities for the implementation of BIM in SMEs.

Considering the results of the 2nd stage presented in this report, the next stages of the project will develop the BIM Implementation Strategy for Links and beginning to implement the strategy on a pilot project.

The uptake of BIM by SMEs is essential for the full realisation of benefits of BIM in the construction industry. In the future, the progress of the project could serve as a benchmark for similar companies in facilitating overcoming the challenges to implement innovation highlighted in this paper.

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BIM Execution Plan Strategy for Collaborative Project Implementation

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1. Introduction

Building Information Modeling (BIM) is currently recognized as an innovative solution that aims to reshape the industries of architecture, engineering, construction and facility management (AEC/FM). This is achieved by integrating a set of policies, processes and technologies that generate a work methodology that is able to manage the building design and project data, within a 3D digital model [1], hence virtually constructing and managing a building throughout its lifecycle.

Over the last few years, various governments have traced strategic implementation approaches to effectively introduce the BIM methodology under a collaborative environment for all national projects, foreseeing the paramount impact of its applicability in the construction sector [2]. The uprising request of BIM allied with the current process of globalization has aroused the AEC firms to the inevitability of implementing BIM in their work procedures, to enhance their international competitiveness. Nonetheless, few organizations/project teams have been able to exploit the benefits of BIM to their fullest potentialities, being the lack of knowledge in implementing BIM in specific organizations and multidisciplinary projects considered the main reason for the unachieved expectancies [2, 3].

Although many standards relevant to BIM exist, there seems to be a lack of framework into which those BIM implementation guidelines could be incorporated for project teams to follow when outlining a detailed plan to reference throughout the project [4]. Furthermore, and equally important, agreements among stakeholders must be generated to define the content of information deliveries and answer to a number of basic who?- what?- when?- how?- questions relating to object and property definitions, need to be improved [1,5].

A potential solution consists on providing a project team with a document designated as the BIM Execution Plan (BEP) that represents a practical methodology to programme a structured procedure that attains to the key factors to consult when implementing a BIM collaborative workflow throughout the stages of a building project, acknowledging the project´s unique aspects, the owner's requirements, the agreements between the stakeholders and the technical aspects to deliberate when elaborating a collaborative project in BIM [2].

This work intends to adapt existing BEP proposals contributing for a strategic guide that conveys a set of methodologies that enables project teams to strategize the implementation of BIM throughout the collaborative project delivery, on the national framework. The suggested procedure is based on six stages which address the essential elements to scrutinize when implementing level 2 BIM maturity projects [1]. Furthermore, a case study is performed regarding a collaborative project between the structural engineer and the architect to optimize and validate the suggested guide.

2. Materials and Method

Firstly, a process of benchmarking was performed regarding the current bibliographical references available, with the intent to retrieve the first-rated issues from existing international BIM standards. Furthermore, existent BEP planning guides employed in other countries were evaluated. Alongside this widespread literature review, various interviews were performed with professionals of the AEC industry who are well recognized by their national and international experiences in the construction industry, namely in the architectural, structural engineering, project management and BIM implementation fields. Finally, the results retrieved from the bibliographical review and the performed interviews were conjugated, analysed, optimized and established their practical implementation on a case study.

2.1 Proposed BIM Execution Plan Strategy

The BEP design strategy developed in this work enables a project team to develop a BIM implementation strategy by addressing the necessary BIM uses to deliver throughout the project. Therefore, this guide has the particularity of representing strategies that grant the implementation of BIM as transversal or partial project methodology. The proposed BEP guide presents an implementation framework comprised of 6 stages (see figure 1).

Stage 1 is the compilation of the basic information of the project, such as generic project information (i.e. name, owner, localization and so forth), basic technical information and information relative to the stakeholders involved. More important, this stage comprises a procedure that analyses the characteristics of the project and the client's requirements being defined and prioritized, the main project goals and tasks of the building design. Potential BIM uses are listed accordingly to the main objectives initially concurred among the stakeholders. Stage 2 attains to the selection of the potential BIM uses, delineated in stage 1, that are to be implemented throughout the lifecycle of the building. A protocol for defining the roles of each stakeholder towards each particular BIM use appointed is performed. Following the selection of the BIM uses to be undertaken, process maps are devised with the purpose to represent the workflow and interactions, in terms of information exchanges, between the BIM uses of the project, stipulating in this way the future relations among stakeholders throughout the project delivery. All process maps follow the Business Process Modeling Notation (BPMN). Stage 3 determines each information exchange that occurs throughout the project, with the determination of the minimum information requirements needed to be performed, and due consideration of the specific BIM uses outlined. Stage 4 and stage 5 study the management required in terms of BIM models interaction and their data administration during the project delivery process with the intent to prevent interoperability issues concerning software application and collaborative workflows among the involved stakeholders. To conclude, stage 6 addresses the various quality assurance checks of the developed BIM models that should be followed to guarantee an efficient BIM collaborative project workflow.

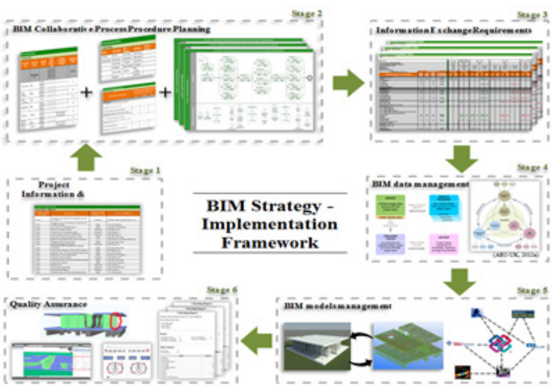

Figure 1 – Schema of the BEP Strategic Guide [5].

Figure 2 - - Case Study, Architectural design (CNLL).

2.2 Case Study

The case study consisted on the development of a male and female camping sanitary facility of a single floor (see figure 2). For the development of this case study the design-bid-build contractual project delivery agreement was embraced, with the intent to simulate public constructions where that contractual agreement is mandatory accordingly to the Portuguese national regulation. Furthermore, the IFC 2x3 format was adopted as the only format for information exchange among the members of this case study project team.

3. Results and conclusions

The implementation of the proposed BEP strategic guide in the case study revealed to be effective, enabling to plan an efficient collaborative workflow, foreseeing and averting possible incongruities between the stakeholders throughout the project delivery. Figures 3 and 4 present some of the deliverables included in the BEP of the case study.

The main results obtained with this study highlight the importance of classifying, under a vivid simple grading scale (such as the LOD Specification Document 2013), the minimum modelling and information requirements of each component of a specific disciplinary model, acknowledging the BIM use and phase of the project in order to perform a productive workflow. Equally significant, is the importance of evaluating and certifying AEC firms regarding the execution of a specific BIM uses, being conclusive and irrevocable the need of a reputable national/international entity capable of categorizing the capabilities of an AEC firm towards specific BIM uses.

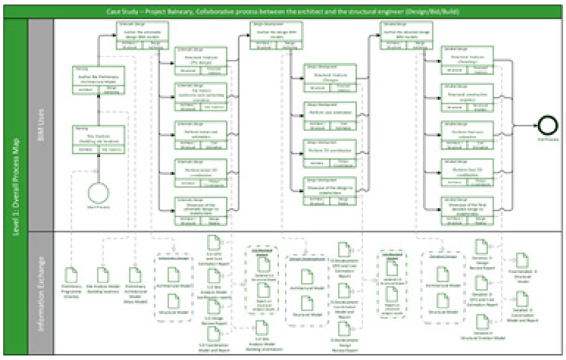

Figure 3 – BIM Overview Process Map – case study [5].

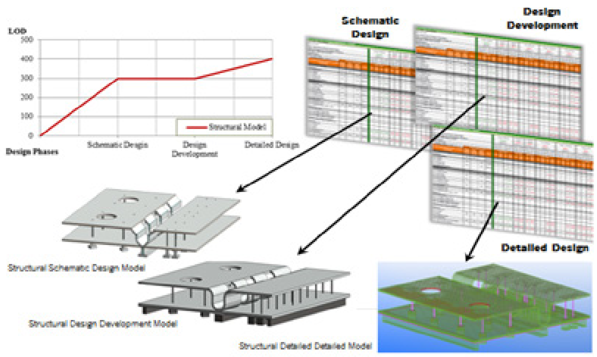

Figure 4 - Level of development of the structural BIM model throughout the project phases [5].

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ProjetoBIM @ FAUP | New ways of thinking architecture at Oporto architecture school by the introduction of BIM methodology in teaching curriculum

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1. Introduction

The central aim of this paper is the introduction of BIM methodology in Oporto Architecture School curricula and how it may change the practice and teaching of architecture, project thinking approach, and in the end the whole AEC sector and even in buildings´ management and maintenance industry. It is intended to intersect architecture and engineering teaching methodologies identifying future professional practice transformation by BIM methodology use and therefore foresee changes needed to be made to current universities´ curriculums. This paper will look through ProjectoBIM course as a single case study in Oporto School (FAUP) where design is our traditional brand image.

Architecture is a vast discipline characterized by complexity. At one hand it requires a great deal of specialist knowledge and at on the other hand it demands a broad scope of interconnections with other fields. For those reasons teaching architecture requires the development of many different cognitive and practical skills. Worldwide university schools offer many different teaching focuses, but rarely on drawing. In this context, and focusing on drawing the Oporto University in Portugal has developed in the second half of the XX century a unique and original course in architecture [1]. How to introduce BIM in this classical architecture course is a great challenge for all of us. ProjectoBIM is a whole new discipline in the architecture course curricula. This paper will discuss the ups and downs of the implementation of this methodology in this renowned and awarded architectural school.

2. Materials and Method

FAUP research group Architecture and Modes of Inhabiting has been conducting research – studies, assessments and surveys – on BIM implementation in the profession practice and in construction market during project development. In that way it has assumed as an observer role over this methodology that lacks definition in its implementation. From the literature review performed the group realized that some steps had already been taken in BIM methodology research. Generally supported by market needs and results driven the assessment of stakeholders´ benefits, changes introduced by this methodology, was evaluated in relation with employment market and in the way architecture is realized, how architecture project is conceived and what is this new type of project/architecture. The introduction of digital tools in creating and designing process definitely affects the outcome and architecture own identity [1]. Consequently it proves to be of extreme importance to study the potentials and limitations of these tools and methodology and the influence over design and development of architectural process production which basically has been performed based on an optimal understanding of the process of BIM methodology integration in labor market and in construction industry.

In relation to teaching, scarcer investigations have been carried out and there is still no concrete study about this approach to implement this methodology in architecture schools. It started as a simple expected evolution of CAD and later on by the substitution of the simple three dimensional rendering engine by a database integration using all the information and data of the model that this methodology incorporates. Subsequently this experiences (the introduction of a 3D model merely as a communication tool) turned out to be irrelevant to the study and deepening of this new approach in the teaching of architecture facing this new reality whose concepts BIM methodology incorporates, with a synchronized and integrated design process [2] contrasting with the traditional design and conception process, based on partial and sequential vision [3] of independent specialty whose information integration is only performed on a much advanced stage.

The "Building Information Modeling" (BIM) is currently perceived as one of the most developed methodologies for the conception and production of projects for the Architecture, Engineering and Construction (AEC) industry. In this sense it announces a paradigm shift in the way architecture and other specialties are performed. Thus, it becomes necessary to investigate process changes and how curricula can be adapted into a collaborative approach that has to be implemented and intends to be accomplished these goals by this research phases: (i) collect all the information on educational experiences in order to implement BIM integrated methodology, (ii) evaluate the process and experiences, (iii) discuss and present results, (iv) synthesize and systematize methods of BIM implementation in architecture teaching, (v) test the introduction of the methodology in a real environment, and finally (vi) review the results and disseminate information held by the introduction of the course in ProjetoBIM at Oporto Architecture School.

3. Results and discussion

The methodology to the implementation of BIM methodology in this course, was organized in four steps:

- Project and Team (1) Redefining project team - mutual recognition of skills and staff hiring; (2) Redefining project timetable - Sharing responsibility and commitment to goals outlined; (3) Actions schedule and of system validation and evaluation during project;
- BIM Methodology (1) Map of major studies and research on BIM methodology; (2) Survey of real context BIM application; (3) Architectural Education; (4) Review of course programmatic structure and pedagogical methods used in architecture FAUP´s course; (5) Review of course programmatic structure and pedagogical methods used of major national architecture courses; (6) Review of course programmatic structure and pedagogical methods used of major international architecture courses - current trends and latest updates;
- BIM methodology integration in architecture teaching International examples and experiences;
- ProjectoBIM Program Creation (1) Promote, experiment and develop theoretical and practical knowledge of BIM methodology comprising the basic concepts during Architectural Project development as a process for innovation, research, management and architecture construction; (2) Promoting research on Architecture through project development simulating a real context of multidisciplinary and collaborative practice; (3) Collecting knowledge about BIM methodology application in international context in the vast AEC fields (architecture, engineering and construction) analyzing business context experiences and case studies and assessing advantages and disadvantages of applying the methodology in the production of an architectural idea; (4) Use of available tools in order to apply BIM methodology in the development of a practical project developed by students and an existing building case study; (5) Learning outcomes and competences maturity.

The expected results are based on the program and defined set of goals that will enable the student to acquire technical skills and scientific competences by the understanding of concepts in Project and Construction fields as well as acquire the capacity of interaction, production and application of BIM tools and methodology by conducting a collaborative project. To that extent, the student will develop specific skills in: (i) the domain of building virtual 3D, 4D and 5D models, (ii) architecture, design and engineering project and simulation processes, (iii) acquisition of interdisciplinary coordination concepts; (iv) LODs level of development; (v) production of design and construction documents from BIM models.

The subject of the course includes the study and exploration of Project Architecture and Construction fields, based on the Project applied BIM methodology, held by several teachers and BIM experts presentations who will support this course. The specific program of this curricular unit will address the following matters:

- BIM, a new approach to the project. A working methodology. Collaborative working tools.
- BIM and architecture, a paradigm shift.
- Concept of interoperability of BIM platform, relationships maps and information transmission.

• Families and parameterization. Creating communication models. LOD concept.

• BIM and the different stakeholders in the Project.

4. Conclusions

Introducing the teaching of a new and different design methodology in a school where tradition aspects of drawing are deep-rooted can't be presented as a straightforward task. Several issues are pointed out as drawn conclusions: (i) the doubt in accepting the challenges of the future and the need to control and dominate a new process to communicate, new ideas of architecture that somehow rendering digital architecture can offer – without falling into a "automatic architecture" approach: automatic elevations or in an automatic or uncritical architectural solution – is still a problem that a single year of ProjectoBIM course implementation in Oporto School curricula cannot yet solve; (ii) the apprehension in the possibility of losing identity during the implementation process and the lack of knowledge and tools to support the design are, both, barriers to the development of BIM in schools with great tradition of drawing; (iii) However, the wide acceptance by students and the massive enrollment of foreign students as well as market growing need of highly skilled BIM technical labor reveals the need for curriculum change and teaching strategies showing students great receptivity in the use of BIM in design process since the first year of the course.

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The new reality on Project Licensing: Case study

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1. Introduction

This article comprises the new realities imposed by the BIM methodology, the impact and changes that it implies on the traditional systems of Project Licensing. Over the years, the design representation methodology used by AEC evolved resulting in different formats of submission in the competent authorities (Drawings, Digital 2D and now 3D) forcing the validation method to change as well. The question now is: How will we validate BIM 3D projects? In Portugal they are validated in the City Halls, regarding Municipal and National regulations. They consist in several documents of different categories, such as Municipal Plans, Urban and Edification General Regulations, Accessibility and Security Regulations. Different regulations aim to ensure the architectural design in its capacity/quality of response to the different needs of the human being, as well as their integration into the city surrounding, which is part of a grid, with rules and guidelines for urban growth. Currently we are faced with two realities regarding submission formats: printed drawings and written pieces, digital formats and written documents (Pdf). In most up to date City Halls, DWF (Design Web Format) is the delivery format used and it reflects the reality and development of CAD (Computer Assisted Drawing) software. A team composed by different specialties technicians analyzes the projects received concerning the regulations, approving or disapproving the licensing. This whole process is very technical and demands deep analysis of hundreds of drawings, resulting in a long response time by the City Halls, with the consequent impact on investment plans made by Owners.

Given the evolution of the AEC sector and undeniable emerge of BIM methodology in the Portuguese reality, some questions arise: How will BIM projects be licensed in the City Halls? What would be the advantages of introducing BIM in the current Licensing process?

The study presented in this article aims to raise the possibility of converting the existing Regulations and Decree-Laws (Figure 1) in a rule software package for semi-automatic verification of BIM designs. The methodology highlights the capability of the software in enabling the customization and configuration of rule sets for automatic verification.

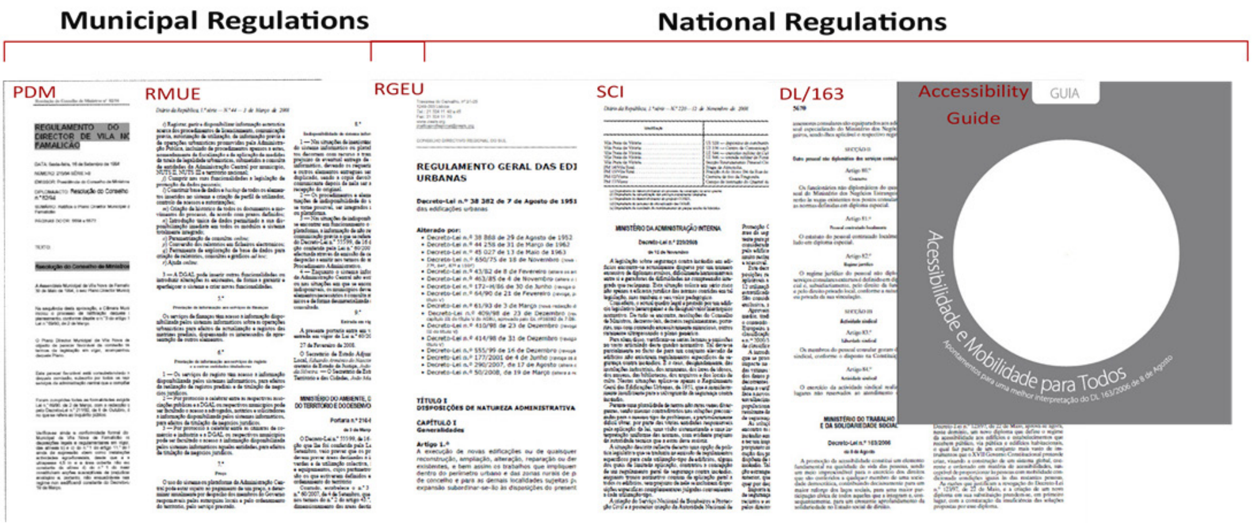

Figure 1 – Municipal and National Portuguese Regulations for Project Licensing.

2. Materials and method

It was used as a case study, the BIM model of a Primary School located in Vila Nova de Famalicão, Portugal, where it was tested a set of selected rules from the current regulations and decree-laws. Initially, it was performed the analysis of the National and Municipal regulations, such as:

National: Decree-Law 163/2006 Accessibility; RGEU (General Rules of Building and Urbanism), SCI (Safety against Fire);

Municipal: PDM (Director Municipal Plan), RMUE (Diretor Municipal Regulation).

Then we've selected some items of each regulation and proceeded to a parameterization work of a rule set in the Solibri Model Checker. After this, it was performed a licensing simulation of the BIM model in use (Figure 2).

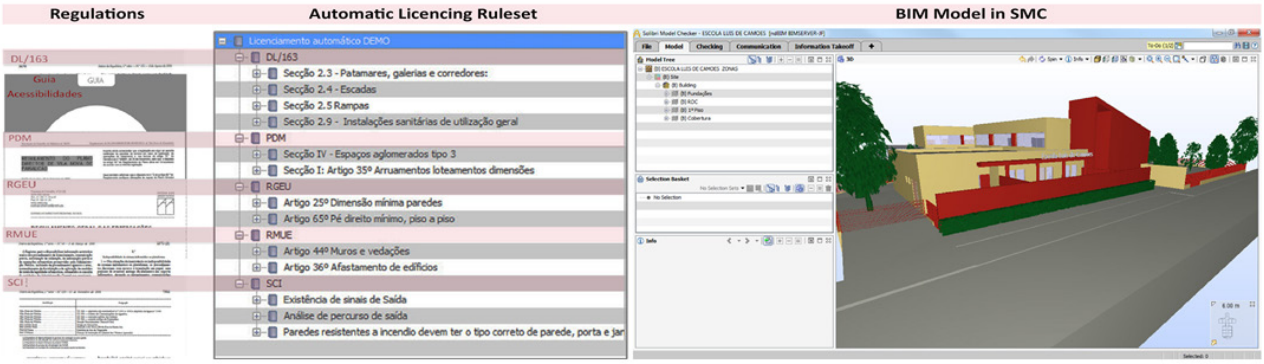

Figure 2 – Case Study analysis process

2.1 Model Quality Assurance

When we talk about the BIM model, we speak about information, which serves as a mean for design, physical scheduling, budgeting and energy analysis and facility management. This requires a high quality model as similar to the reality as possible. Only this way it will be possible to extract correct information and enjoy the benefits of a BIM model. The quality of the model can be ensured largely by the analysis of Solibri Model Checker (SMC), which can detect errors in modeling, intersections between specialties and errors in the design of the Project. Taking advantage of this process, we believe it will increase the advantages of a BIM Model, if we can use it, as well in the Licensing Process, which is one of the main parts of the Project.

2.2 BIM Model Requirements for Licensing

Given the objective of exporting the model to Solibri Model Checker from IFC (Industry Foundation Classes) format, it was necessary to understand the modeling requirements needed for the correct exportation of the parameters, in each object, and therefore its interpretation according to the SMC rules that we've parameterized. For a correct model analysis we have noticed that it is necessary to stablish rules that assures that is possible to extract the information needed, e.g.: height, width, thickness of certain objects.

In other words, we have realize that the BIM model for planning and extraction quantities must have different requirements in regards to the licensing one, as the first ones concern geometric information and the second one are related to non-geometric such as IFC descriptions, layer information among others. This doesn't mean that we must have different models, only that a standard has to be developed that serves everyone.

It was also important to understand how the regulations regarding the implantation in the urban area could be analyzed. We concluded that it would be necessary to model a portion of the city just with volumes in order to compare them the Building itself, especially while the rest of the city is not modelled (Figure 3).

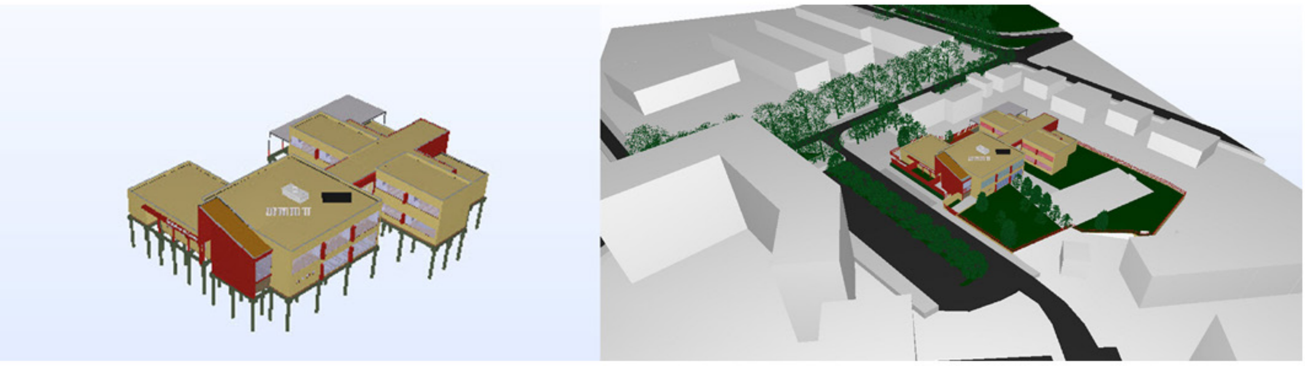

Figure 3 – Architectural Model / Site Model

3. Results and discussion

Concerning the "National Regulations", it was possible to simulate on the model problems related to Accessibility, particularly related with the areas of free circulation, bathrooms of conditioned access and free routes, through the parameterization of the rules in accordance with Decree-Law 163/2006. Software proved itself as quite effective in this kind of study, as well as detecting incompatibilities regarding fire safety. Rules were developed, e.g.: for the analysis of escape routes, for the existence of exit signs, verification of opening doors direction and the analysis of the existence of the correct door types and windows in case of fire protection. In the "Municipal Regulations" the purpose was to evaluate clearances, building highs, etc. through SMC.

4. CONCLUSIONS

What we can conclude is that the Licensing through BIM models is a vision that can become real very soon, with the submission to the City Halls of models in IFC format. Some procedures and regulations of the current licensing are extensive and complex documents, but if they turn into more objective documents, we can be able to easily parameterize in SMC the legislation featured in them. Automatic Licensing can make the process more objective, simple and efficient.

The goal is, with the possibility of using BIM, it will be important to take advantage of the investment done in the model and use it in all its potential for the design, coordination, construction, FM (Facility Management) as well in licensing.

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Agile BIM Design Development

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1. Introduction

It is difficult to establish a stable, long-term vision that defines all the requirements for the Architectural, Engineering and Construction (AEC) design process life-cycle due to unpredictable events that occur along the process. Design changes in later phases are frequent and that implies a considerable amount of rework on all fronts, thus resulting in a very inefficient process.

This problem has been addressed in the software development industry using dynamic planning methods that are capable of dealing with high degrees of unpredictability. These methods, known as Agile, were introduced in 2001 in "The Agile Manifesto" [1].

The AEC Design development shares many characteristics with Software development insofar as both activities are developed under significant uncertainty considering both the product specifications and the methods that are required to develop them; the main difference being that the AEC design information is scattered through many disciplines and documents. Tracking, coordinating and managing all this information, rapidly and systematically, was a daunting task, which made it next to impossible to implement an efficient Agile workflow for AEC design development.

This represents no longer a problem with BIM, as it provides a dynamic and collaborative platform that centralizes all the design information. BIM leverages Agile, in that it allows more collaboration between design disciplines at earlier stages, to easily explore design options and to add changes with little effort; and vice-versa, in that by applying Agile methods to a BIM-based design workflow, one can increase the quality of the design and the efficiency of the process.

This paper explores the dynamics of applying Agile methods to a BIM design process, supported by the practical application of such methods to the BIM-based structural design development.

2. Agile methods

The traditional process is often compared to a waterfall (Figure 1) where the dependencies and duration of each task are clearly defined for the whole duration of the project. In this process there is a high degree of dependence on previous tasks, hence any design changes will necessarily result in the return to a previous design stage.

On the other hand, the Agile process can be divided into a set of work cycles. The whole project team is involved in each of these cycles. At the end of each cycle, potentially shippable products are released and refined successively (Figure 2). The Agile methodology is thus described as iterative and incremental. This methodology presumes that the general direction of project development will be re-evaluated recurrently and it allows the team to make changes in early stages, thus reducing development costs.

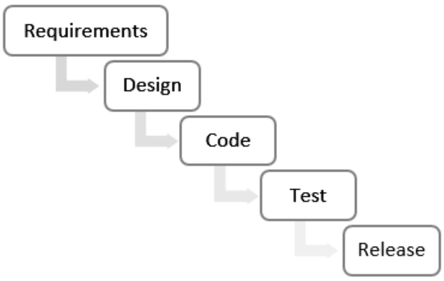

Figure 1 - Tradicional "Waterfall" (software development).

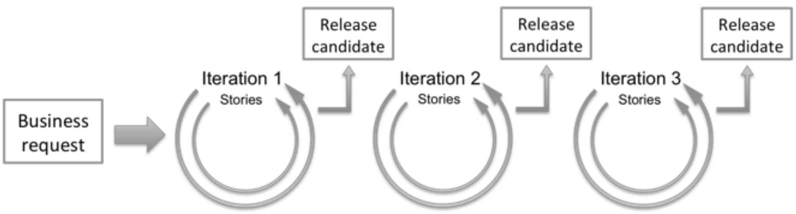

Figure 2 – Agile method (software development), adapted from [2].

Several production frameworks employ similar principles to Agile's but with specific characteristics such as cycle duration, ability to incorporate changes during cycles, among others. Amongst the most popular frameworks are SCRUM, Kaban and XP (Extreme Programing) [2].

A recently proposed iterative project development methodology named Concurrent Engineering (CE) [3] promotes early error detection and the identification of opportunities for improvement, while maintaining the cost of design changes at a relatively low level [4]. CE restructures the entire process of project development involving all stakeholders (owners, designers, builders and suppliers). The methodology relies on a tight integration of applications between different design teams, on parallel engineering and on continuous, iterative cycles. However, the application of this model leads to major challenges since it forces a level of understanding and coordination between stakeholders that is not always easy to achieve. Since Agile methodologies favor the management of small, co-located teams, it is easier for architects and engineers to implement these methods on their internal processes. As long as the global structure of the traditional design process is preserved, each design development team is free to change and enhance their internal workflows. Agile methodologies are therefore easier to implement in small and medium design offices, whose ability to interfere with the overall project development process is usually limited. Bigger firms are likely to follow these, should Agile methods prove themselves to be feasible and lead to benefits.

3. Bim-based agile design development

Regardless of the framework that is adopted, the development of a project begins with a requirements analysis. In a BIM-based project, the definition of the Level Of Development (LOD), the scope of the modeling process and the selection of data exchange formats are examples of project requirements. The first cycle begins at this stage. Under a SCRUM framework, the product backlog - a list of products to be developed, in this case, BIM deliverables - is then defined. Every workday begins with a meeting, formal or informal, where the list of products is reviewed. From that list and according to the established priorities, a selection of products to be developed during the workday is quickly identified. Every team member is then assigned with specific tasks and working strategies to develop each product.

Normally, this workflow would not be feasible as it would take too long to track the progress of the development of the project, making these strategy meetings too time-consuming and thus unproductive. BIM enables this workflow by making it easy to quickly assess and communicate both specific and overall progress.

In the case of structural design, requirements are usually defined by the Architect. The backlog might include dimensioning or detailing specific elements, and the production tasks classified in several development stages such as: "To do", "In Progress", "Verify" and "Done". An example of leveraging BIM for this purpose is to assign, as an explicit parameter, the development stage of each structural element to the corresponding BIM object. This information can then be easily accessed in schedules, databases or even visually, by configuring the model's visual properties to display different development stages with a color code (Figure 3). With a simple add-in, it is possible to export and store, in a common database format and on a daily basis, the project progress information. This data can then be used to create progress indicators and graphics. A web-based application that provides progress reports has been developed at bimTEC (Figure 3) and proven successful in allowing the team to quickly evaluate and report both the daily and the overall design progress.

BIM's collaborative dynamics allow various users to work on the same model simultaneously, which means, each user has instant access to the model's development stage according to the latest updates. Upon the conclusion of a certain task, users can easily proceed to the next one without having to wait for new instructions. Furthermore, immediate access to this type of information allows a quicker definition of new work objectives, which adds flexxibility to the definition of daily activities. The team becomes highly adaptable and able to answer client and other design teams' requests faster.

Combining Agile methods with BIM is an excellent way to increase the productivity and overall quality of AEC projects. These methods and tools are highly compatible (Figure 4), with their simultaneous implementation resulting in mutual benefits.

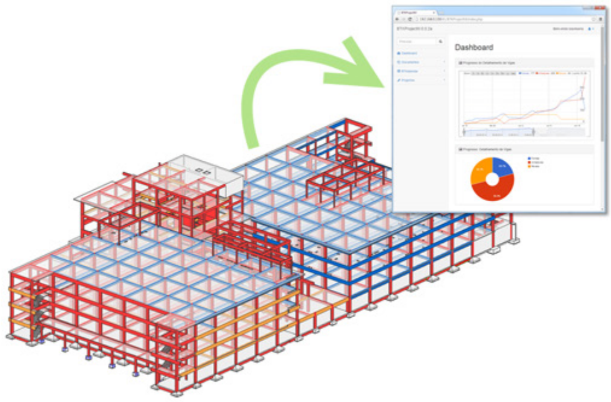

Figure 3 – BIM-based project development progress reporting tools.

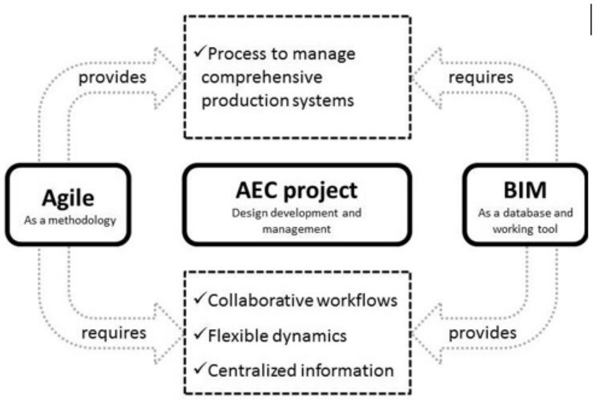

Figure 4 – Agile and BIM dynamics

4. CONCLUSIONS

This article demonstrated one way to leverage BIM in order to implement Agile methods in the development of AEC projects and vice-versa. Agile methods have been widely used in the software industry to handle uncertainty in planning. The application of these methods to BIM-supported design development enhances the communication and collaborative capabilities brought by BIM, increasing workflow flexibility and productivity. Design teams are able to more efficiently set and adapt to new daily objectives and thus reduce the impact of uncertainty.

Agile methodologies should be seen more as a guide to solve a problem than as a restricted set of rules for design development, and their symbiotic relation with BIM fostered in several ways.

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Cross cultural assessment of the usability of parametric CAD software in architectural design practice and education in Brazil

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1. Introduction

The research initiative described herein comprises the assessment of marketed parametric CAD software packages in architectural design practice and education in Brazil. The construction industry began a transition from manual drawing to CAD in the 1970's and this was straightforward as there was little change in the design process, less than what was initially thought for CAD applications. Parametric CAD software became available in the early 1980's and had to overcome several cultural and technological barriers before being widely accepted. In the 2000's, the construction industry, in pursuit of better tools and methods, for higher efficiency, has changed the design process towards BIM, IPD and FM. Parametric CAD software has evolved from 2.5D to 3D single building modelling, to parametric design, on to concurrent design environments in support of BIM, at least in stated proposal. There are still issues to be solved and also cross cultural problems to be addressed. Our continued research is motivated by known differences in: the representation of building elements and annotation, level of detail within a design phase, design documentation, and construction culture, between Brazil and the United States or Europe. We aim to provide guidance on best practices regarding representation, design documentation and of the design process in a concurrent environment. Our studies also produce tutorials [1], for marketed parametric CAD software, that focus on the design process as opposed to the tool centric, and linear design (fault free) approach, vendor provided materials.

2. Materials and method

The method consists of the confrontation of design documentation requirements for a given phase sequence, from conceptual design to detailed drawings of the intended building construction, as specified in National standards, specifically [2,3,4]. This approach addresses the proper documentation and representation of construction and annotation elements for the chosen phase(s).

The assessment of the design process requirements, considering the type of decisions and changes that typically occur within each design phase, and of concurrent design, are not as straightforward as the representation and presentation perspectives. They have been gradually inferred during work development and literature review ([5, 6, 7, 8]).

We started from a simple architecture brief of a commodity type building [9]. We aim to progress towards more complex buildings, also from single handed Architectural design only, towards multidisciplinary collaborative (concurrent) design, incorporating other building systems into the appropriate design phases, in a non-linear manner. Each step in either direction involves one or more undergraduate students and their corresponding individual scientific initiation research projects. The problem to tackle and the software package used is chosen by each student, but are based on what has been done previously in this line of research.

In each experiment, two tables are produced, starting from templates with the corresponding requirements and gradually filled with the corresponding findings. We don't state what each software platform is capable of, but rather what we accomplished with our knowledge of the given application. This issue is later sought through vendor feedback.

The first table covers the static requirements of representation and presentation, organized in hierarchic form. Titles are Construction elements, Building systems, Components and Documents. Subtitles in each case refer to the pertinent types, respectively: Foundations, structure, walls, floors, stairs, roofs, etc.; Electrical, gas, water, ventilation, etc.; Windows, doors, sanitary, kitchen, etc.; Plans, elevations, statutory, guidance notes, bills of materials, etc.

Each item (building modelled element or component, or presentation element) is a requirement and has corresponding: (a) achievement, (b) interoperability (when applicable) and (c) a reference to the corresponding tutorial section (the operational example) values in the appropriate line and column.

The second table lists the dynamic requirements and findings (using the selected software) regarding the design process for the chosen Architectural Brief and Design Phase(s). This is the common ground for the development of best practices for BIM works, although each software platform operates in a different manner. Necessary attributes for classes, instances and parts of instances; and expected behaviour of building elements and spaces, especially when displacing, merging, connecting, inserting into one another or linking to references, are examples of such requirements.

3. Results and discussion

The initial study object was a house with a floor space of not more than 70m2, that the students had previously drawn in 2D using CAD on the 3rd or 4th course semester. The purpose was to learn the basic usage of each software with the vendor provided tutorials while gaining BIM knowledge by reading through the referenced bibliography. Then produce a more realistic tutorial, specific for the chosen building and design phase(s), including a simulation of the conceptual phase, more specifically finding a suitable topology that met the architectural brief followed by a corresponding feasible geometric dimensioning, as proposed for a similar situation by [5].

This was done in different times by four students working with software from three distinct vendors. The first and third experiments were done using the same vendor software. The later aimed to improve on the first, also benefiting from a newer software release and feedback from the local vendor. This rework was necessary due to our lack of knowledge of usage of the chosen software, actually of any parametric CAD.

In the interim, another student started a new thread using another software platform. The learning effort in this case was almost overwhelming because it is built over a traditional CAD which becomes a pre-requisite. Anyhow, the student also managed to deliver the research results and tutorial, that were both analysed by the local representatives and valuable feedback was given. Although the organisation of information and tool definition and usage differ from one software vendor to another, this second assessment benefited from the results of the first thread.

The fourth experiment inaugurated another thread, with the same architectural brief, using another widespread parametric CAD. This third software was perceived as the easiest to learn, although somewhat more difficult when pursuing dimensional precision of design elements, during the geometric dimensioning phase. It also benefited from the work results and overall knowledge gained from the previous assessments, although the differences in the organisation of the information, and tool definition and usage.

4. Conclusions

Work progress depends on student interest and corresponding funding in the form of scientific initiation research project grants from government agencies or within the University. Research projects are limited to one year. In this time the student must study the suggested references on BIM (and seek further readings), the vendor provided tutorials, and the results from previous projects. The student must produce a research report that includes the table of requirements and related achievements for the chosen architectural brief, software and design phase(s).

Each resulting table set adds up to the overall knowledge of the design process using parametric CAD and also of BIM. The tutorials produced are also made available to all students after learning traditional 2D drawing in CAD, not only to make them aware of such technology, but to encourage new research proposals to extend this knowledge. A student in another line of research [10] benefited from using the in-house produced tutorial rather than the lengthy sequence of vendor provided traditional 2D CAD, 3D CAD, then Parametric CAD tutorials.

Since the requirements are the same, the analysis of resources, tools, definitions and behaviour, by different vendor provided software and also updating due to added functionality provided by new releases is straightforward.

Achieving a full BIM experience involving undergraduate students in Architecture and Urbanism still remains a challenge. This could be addressed through a joint research project with the graduate students from the Civil Engineering course, within the University.

5. Acknowledgements

The authors would like to acknowledge the under-graduate students in Architecture and Urbanism who contributed to the overall research, through their individual scientific initiation research projects: Fernanda Invernise de Moraes, Guilherme Arruda Cesar, João Guilherme Viaro Correa, and Letícia Juliana Pazian. The authors also acknowledge CNPq – National Council for Scientific and Technological Development, the University Provost's Office for Research, the University Provost's Office for Undergraduate Education, and FUPAM – Foundation for Research in Architecture and the Environment, for the financial support, in the form of student scholarships.

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Restructuring Internal Roles With BIM Implementation

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1. Introduction

In this article, the authors discuss the changes in organizational roles and responsibilities that come with BIM adoption, survey current trends for the definition of BIM roles, and provide some insight into the best way to transition from a traditional CAD process into a fully integrated and efficient BIM workflow.

With the emergence of BIM as a standard tool for design modeling and information management in the Architecture, Engineering and Construction (AEC) industry, professionals strive to find the better, most efficient way to accommodate the technology into their practice. Due to the technical and comprehensive nature of BIM as a working tool, most adoption and implementation efforts are characterized by extremely well defined processes and workflows that aim to regulate and coordinate the considerable amount of information involved in an AEC project [1,2,3,4]. These efforts consist mostly of guidelines to define and exchange information for public projects. It is not uncommon for companies looking to adopt BIM to use these documents as the main reference to create and adapt their internal workflows, redefine roles and responsibilities, and create company standards. While they are undoubtedly a good starting point, it is essential to understand the difference between BIM-based project processes and internal BIM workflows in order to properly adapt a wide ranged life-cycle approach into an internal one.

The introduction of BIM fosters the creation of a whole new set of roles to answer the new BIM-exclusive demands [5]. Bar a few exceptions, these new roles can be filled by the current staff, provided they receive proper training. The key when restructuring internal roles is to identify who is better suited to fill each position. Some are transitions from similar CAD roles; others are completely original and exist because of the unique possibilities provided by the technology. A trend seen in many studies and reports is the clear definition of each figure's unique set of skills and area of intervention. The importance of well-defined hierarchical structures is unquestionable, especially in big companies; however, a certain flexibility regarding the definition and the assignment of BIM roles is, in some cases, not only welcomed but essential.

2. Discussion

BIM roles can be divided into three major types: operators, developers and managers [6].

As the one in charge of building the model, the operator is someone who is constantly interacting with the model and whose work is of extreme importance. This position is often called BIM Modeler and regarded as an evolution of the CAD Drafter, which is not entirely correct, in that, not only BIM Modelers must master specific modeling skills for different design disciplines, they also must deal with a lot more information than the one included in a single CAD sheet. The potential for overall hazardous input is thus a lot bigger in comparison to that of a CAD Drafter. This is why the general trend now is to hire junior graduates to fill this position; it ensures a level of technical knowledge and proficiency at a low cost. On the other hand, the prototype of the architect and the engineer of the future is of a hardcore user who uses the BIM platform to communicate, test and improve his designs. In that sense, he can be described as both BIM Analyst and BIM Operator. Not limiting a BIM Operator to the evolution of the CAD Drafter is an extremely important point. They are usually perceived as the bottom of the BIM food-chain and that assumption may lead to a certain prejudice against the position. A BIM Operator is, in its essence, someone who knows how to use the BIM application; it is the person who will end up knowing the program better than anyone. Without his knowledge and contribution, the BIM process will hardly evolve at all.

The transition from a CAD environment to a BIM one is a delicate process. CAD processes rely on a highly productive task force of several CAD Drafters that work in a mass-production-like workflow. As each Drafter is assigned with a group of isolated tasks, there's hardly any collaborative and dependent work; which is the opposite of a BIM workflow. Furthermore, it is likely that only experienced professional CAD Drafters have the knowledge to fulfill the necessary requirements to assume the role of a BIM Modeler that creates entire models from the designer's rough drafts. The AEC industry is still many years away from a point where the design completely leaves the 2D drawings (if it ever will) and as such, designers will keep communicating using 2D CAD files, therefore less experienced Drafters are still required for a number of tasks. In the pre-modeling phase, to setup the model with cleaned up CAD drawings, and in the post-modeling phase, to prepare the drawings and the sheets that will be submitted as part of the 2D drawing package. BIM does provide a considerable level of automation that speeds up the preparation of the drawings; however, a manual touch is still required to guarantee readability and an overall polished look. It is not iron penned that Drafters transition from and into an exactly similar role. Drafters in the classic sense of the word are still required, though likely in a lower number. Due to the wide range of new BIM-based applications, the surplus may be directed towards different positions. An example would be BIM Graphic Designer, a BIM Operator in charge of creating and refining renders and animations using BIM or BIM-compatible applications.

A BIM Developer [7] can be broadly defined as someone who creates content to be used in BIM applications. Examples include developing custom families/BIM objects, writing small scripts using the BIM Software API and creating BIM-compatible stand-alone applications. This type of position does not necessarily have to be filled by IT personnel or people with a degree in computer science. In fact, the ideal profile, particularly in small sized organizations, is likely to be someone with qualifications on AEC disciplines and with some background on coding or computer programming. The BIM Developer role requires a profound knowledge of the mechanics of a BIM database; it also requires continuous research of the market's latest trends and solutions. It is hard to find a similar role in a traditional workflow; the closest would be R&D personnel. Still, anyone with the know-how and the motivation to undertake this task can transition from whatever role they had into BIM Developer. A variation of this role is the BIM Specialist – an expert in BIM processes and frameworks, able to develop custom optimal solutions for each different scenario. Due to his expertize in BIM mechanics and processes, the BIM Specialist is also the ideal person to provide training and continuous support.

Managing roles are the most demanding as they require a comprehensive knowledge in different domains. The simplest description of this role is BIM Manager. Other iterations include BIM Coordinator, BIM Leader and BIM Job Captain [6, 7]. The simplest version of a BIM Manager role is to be responsible for the development, implementation, management and continuous improvement of the modeling team's BIM strategy [8]. It is someone that prepares the company's BIM standard operational framework, assigns roles and tasks, organizes and consolidates model data, defines interoperability dynamics and coordinates the different model applications. The BIM Manager can easily accumulate completely different tasks and assume the role of the Project Manager, especially if it is someone in charge of a BIM-exclusive design team. It is someone that fully represents the BIM team in meetings with department heads, corporate leaders and clients. The marketing side of the BIM Manager has been described as BIM Evangelist, the one responsible to lobby BIM inside the company and representing the BIM department in client meetings. The potential for such a central role makes the BIM Manager a very alluring job. Architects and engineers can both transition into the role; however, they must also become BIM experts, mastering both theory and practice regarding BIM, and that may also detract them to pursue the position. Besides all the technical knowledge, the BIM Manager must be a true believer and enthusiast of the technology.

The way these roles are assigned changes with the size of the company. In small firms, the level of BIM expertize tends to be evenly distributed. Since the entire team is required to master the BIM authoring software, everyone is able to operate it, at least, at an acceptable rate, with each member then focusing on specific functional areas. This leads to a very collaborative and flexible workflow that translates in members switching between and/or absorbing several tasks at once, for each different project. In such setting, it is common for a team member to act as BIM Manager, Operator and Specialist. In bigger firms, with a larger staff and more ongoing projects, the organization should be tighter and the definition of roles stricter and clearer. The BIM Manager should focus more on operational management and leadership than on the coordination and development of the BIM projects. A BIM Manager could also act as BIM Developer/Specialist, although never as BIM Operator to avoid being overwhelmed with each project's specificities.

It is fairly easy to make a simple operational script that allows anyone without BIM knowledge to perform basic tasks; however, just because one is able to follow such script, that does not make him ready to take on the most basic of BIM roles as they would quickly stumble across all sorts of difficulties. Common to all the BIM roles is the fact that all require a fairly advanced set of BIM skills, which is why it should also be fairly easy for someone experienced in one role to somewhat quickly transition into the other.

3. Conclusions

The transition to a BIM environment is a broad and complex process. The shift to BIM introduces new production dynamics, bringing along a whole new set of roles. These can be filled almost entirely by the same team that was operating in the CAD environment; however, it is essential to understand the parallelisms between roles in order to find the best fit for each member of the team. If some roles are very similar in their nature, CAD Operator to BIM Operator or CAD Manager to BIM Manager, others are not so clear. Furthermore, the transition does not necessarily have to be to a similar role. Depending on one's individual skills and motivations, the new BIM role can correspond to an entirely different type of work compared to the previous CAD-based one. Another important point is that a BIM user can be tasked, simultaneously, to several different roles or only to a very specific one. These dynamics change with the size of the company, the size of the team and the volume of on-going projects.

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A natural model evolution: form Designers to Builders

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1. Introduction

This article aims to demonstrate the importance of the definition of clear modeling processes and use of BIM models by construction companies to avoid cost overruns that can compromise the integrity of the project. Assuming the advantages and effectiveness of BIM in the design phase we will focus our attention in the construction area. This paper is the result of several month of work as BIM consultant and service provider firm for construction companies.

The cost overruns can have dramatic consequences not only with regard to the feasibility of the project to be built, but on the sustainability of the construction companies. Although there are no official figures for the private sector, it is possible to look at the public sector and quickly draw some conclusions. In Portugal, for example, over the last decade several public works have exceeded the initial expected value, having the most critical a cost deviation, in averaged, 94% higher than the initially set value. Besides shocking, this value is an exorbitant sums that demonstrate a real problem in the construction sector. In order to try to answer the purpose of this work was necessary to understand the main causes of cost overruns.

2. Cost overruns – causes and consequences

According to a report presented in 2007 in the 3rd National Congress of Construction (1), the three main causes of cost overruns in Portugal are: first, Design errors; Second, Direct change orders; and finally, Different site conditions. The last one will be ignored regarding the subject of this abstract.

Keeping in mind the two main reasons outlined above, we will try to draw a summarized chronological succession corresponding to the various stages of the process that culminate in the construction of a building, in order to understand the impact, or rather the consequences of the problems mentioned above. At first, we have the design phase. It is precisely at this stage (consisting of several moments corresponding to the various legislative stages and respective degrees of definition) that occur most of the project errors. Assuming, as already mentioned, the effectiveness of BIM in the design phase, we will certainly take into account that the designers remain human beings. Mistakes were, are and will be made, what we want is to control and minimize the impact of these errors in the following phases.

Once all trade designs are validated, these are delivered to the companies responsible for its construction. Before starting the construction, projects go through several phases that we will describe. Initially, projects go through the measurement phase. All the components of the project - in this case the BIM models from the designers - are measured and quantified in order to understand exactly the consumption of materials and workmanship required for the construction. Once completed the measurements and based on historical information of each company - such as productivities – the deadlines to complete each task are calculated. Once calculated the amount of workmanship and materials as well as the deadlines, it is calculated a budget that indicates the expected value of construction. Once validated this budget, begins the construction of the project.

Being these three stages interconnected, any error in one of them will have direct and negative influence on the next one.

Unfortunately, the reasons stated above as the main causes of cost overruns difficult the entire process since design errors often lead to quantification errors and consequently planning and budgeting errors while making changes requires to conduct further measurements, which makes the process last longer.

Ideally, with the use of BIM tools, this temporal succession may seem simple: based on BIM models delivered by designers to construction companies, would be automatically calculated the necessary resources and in turn planned deadlines and project costs.

In order to minimize the impact of errors and changes described above, it is necessary to ensure a perfect connection between the models of the designers and the following steps leading to the construction of the building. It is precisely this moment, situated between the design phase and the measurement phase that corresponds to a time window in which it is possible to intervene and minimize the risks. Getting a perfect connection between the models of the designers and the measurement and quantification phases quickly and efficiently would dramatically reduce the cost overruns. Any change to the project, in this case the model would immediately ensure an update of the quantities extracted from the models and consequently an update of the time planning and budget.

Although it seems simple, our experience in the construction has shown that the real issue is not only about the quality of the models for quantity-takeoff but also about the type of quantities that we want to calculate from the model.

3. Case Study

If we think about measurements, we will immediately think about national rules and standards that vary from one country to another. The way a quantity of material or workmanship is calculated in Portugal for example is different from the way it is calculated in Brazil, so the results will be different. The most inexperienced in this area may think that each country has its own document that dictates the measurement rules to be applied by all the professionals of the construction area in the country.

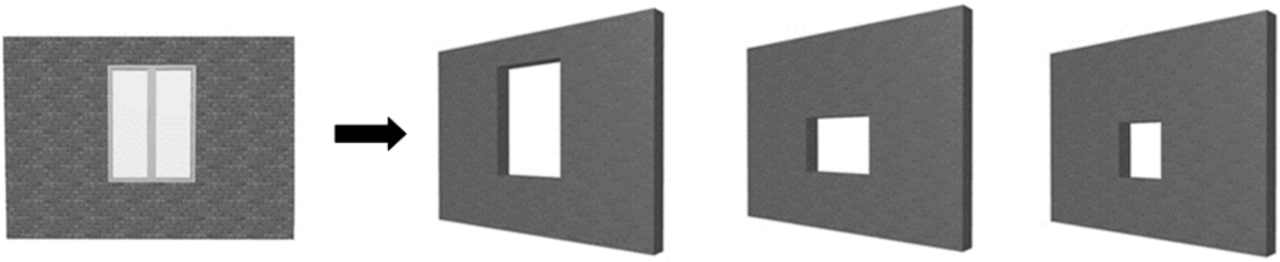
Unfortunately, besides the fact that these documents do not have a legal character - since in most cases they are only recommendations - our experience has shown that the measurement rules and quantification methods vary much more than expected.

As an example, we will use information collected from various implementations that we were involved over the past years in order to demonstrate the difficulties that construction companies have been facing. By analyzing the structure of a WBS (that changes according country and client involved) and quantity measurement rules we have found considerable variations of methodologies applied for the measurement and quantification of the elements. For example, to calculate the workmanship required to build a simple brick wall - measured in square meters - and that included a window, the following measurement rules were found:

- Calculated area = Gross wall area - Window area
- Calculated area = Gross wall area - (Window area / 2)
- Calculated area = Gross wall area - (Window area - 2)

It is important to note that these three methods of calculation and quantification were found in several construction companies in a single city. Unfortunately, this is a reality that happens in every city and every country, which creates communication problems when a construction company has to subcontract another one since both use different measurement rules. To ensure good communication between all stakeholders, it was necessary to find a way to extract the quantities - according to the measurement rules used by each company - from the models provided by designers without compromising these models so that all stakeholders could use these same models ensuring a single coherent database.

The methodology that we applied with our clients consisted initially to clearly define the measurement rules used internally. Understand the operation of each company is crucial to achieve this. To this end, a quantitiy measurement rule standard is created, from information collected over the months, for all items quantified in a WBS and involving the various departments of each company. This knowledge is essential to the creation of internal procedures which allow the extraction of quantities directly from BIM models without errors. Then we implemented a methodology that allows us to use the same model in different companies (designers, contractors, subs, etc) and extract from it quantities that obey to each ones quantities extraction rules. In the end, with this methodology all of them will have the same model, but can have different outputs from it as shown in picture 1.



Picture 1: On the left, the original wall from the designers. On the right, three walls modeled according to the mea-

4. CONCLUSIONS

What we argue at ndBIM Virtual Building is that the definition of internal procedures is equally or more effective than the BIM model itself. What is really important is to understand the inner workings of each company once that a single BIM model won't be efficient if you do not know what you want to do with it. From the moment is clearly defined what kind of information is intended to extract from model, this information combined with a strong knowledge of BIM software allows the definition of procedures and methodologies that enable the use of a single model for design, quantify-takeoff, planning, budgeting and construction, and this, by all stakeholders.

What we have learned over the past few months with our clients is that working all together with BIM models, servers, clouds, openBIM files etc., is not enough. The most important in each and every company is working all the same way.

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Methodology for quality control of BIM models for 4D and 5D analysis

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1. Introduction

The study to be done in the ambit of the dissertation of the Master in Civil Engineering with the collaboration of the company ndBIM Virtual Building, which aims to promote the use of BIM and expedite their integration with new conclusions about quality assurance rulesets.

Nowadays, the construction industry is changing. Every day emerge new and important challenges. The increased information and the need of finding new and sustainable practices that result on the higher productivity, lends this industry to opt increasingly for modernize and automation solutions [1].

BIM Modeling Building Information is a methodology consisting on a set of policies and technologies that lead to virtual and digital control of all phases of construction of a project. Collaboration and sharing information between the various stakeholders of the project is now mandatory, in order to aim good results. This collaboration creates digital documents which allow us to simulate reality. Between features and capabilities in the life cycle of a building, provides the visualization and documentation, automatic measurement, software integration, compatibility between specialties, planning and control of time (4D), planning costs (5D) and maintenance / operation (BIM FM 6D).

4D/5D-Visualization is an emerging area and presents the ability to simulate the construction process with the additional temporal dimension, which makes the virtual model easy to analyze and plan for the sequence of activities. 4D/5D visualization facilitates minimizing rework, which has the highest impact on profitability. Nevertheless, owing to the interfacing among several software applications, the process of creating the 4D/5D model is often time consuming and it requires a definite skill-set to develop an effective 4D/5D model. The 4D visualization is widely adopted in industrial projects and has proven to be effective and useful. However, due to constraints in time and budget, 4D/5D-Visualization has not been quite accepted in the residential and commercial projects [2].

This study, will focus on the planning and control of time (4D) as in planning costs (5D). One of the major problems of BIM that occurs when these specialties are considered, are the errors in the extraction of quantities which leads to a incorrect budget, that for its turn, can result on the loss of a work and profit by a contractor. It was here that emerged a very important phase of BIM, the quality assurance models.

The efficiency of a collaborative working process of BIM depends on whether the necessary information inherent in a BIM model/project that is available in the delineated, which is precise, and if it follows the requirements of proposed modeling [3].

According to the Finnish standard for BIM, quality assurance is focused on checking the quality of building designs according to what BIM-based design currently enables. It should be noted that depending on the field of design, quality assurance has many other tasks beyond what can be done with BIM. The main goals of Quality Assurance are twofold: first, the quality of each designers own design work shall be improved and secondly, the exchange of information between the parties, thus also making the overall design process more effective [4].

The main objective of this study is to identify a group of rulesets who can be used to check models, based on verifications in three case studies and the study of COBIM2012 contents.

2. Materials and method

The research work to be developed in partnership with ndBIM Virtual Building Company has as main objective find solutions in quality assurance that improve the use of BIM methodologies and consequently enhance the quality of construction transforming the BIM a suited tool for construction sector.

Initially, approach passed through a phase of analysis of existing information about the theme 4D and 5D BIM, in the national and international community and a collection in online libraries available to students was carried out. On the second phase, was discussed the triage made and presented the information gathered.

The development of the case studies of dissertation was used a BIM program, the Solibri Model Checker at the beginning we will review the rules of the program to the standard referents COBIM2012 and the result was a spreadsheet , with all the parameters that can be modified.

Concluding the previous step, was import design/architecture model from an Archicad file to IFC and their respective assessment following the same rules of the program, Solibri Model Checker, making a summary of the errors at the end. The same work was done to the project / model structures as shown in Figure 1. After the analyses of the cases of study a group of rulesets, appear based on the cases of study and COBIM2012, to avoid in model building.

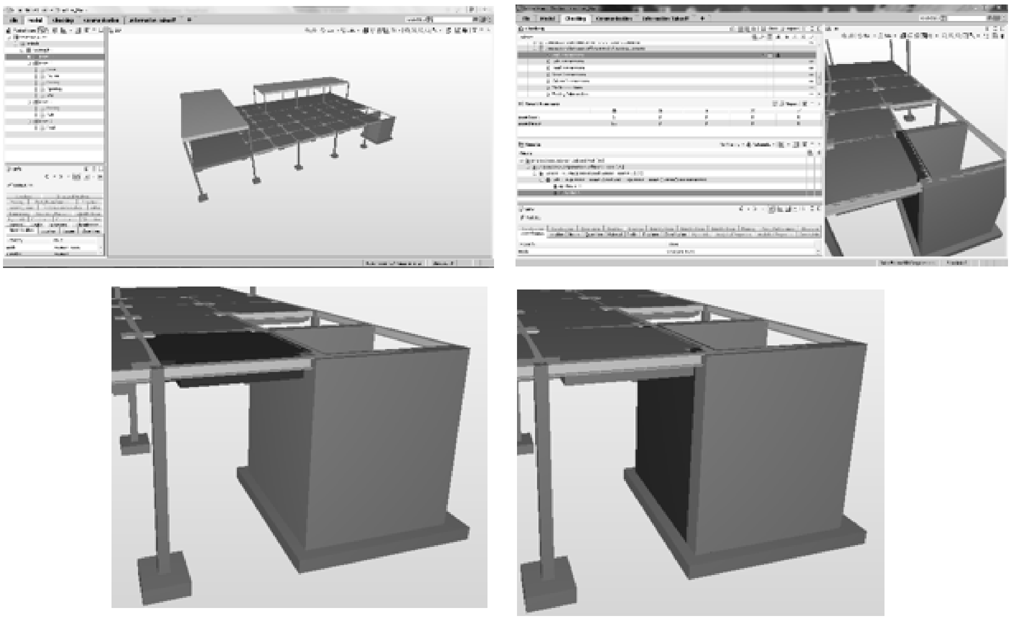

Figure 1-Detail of Quality Assurance Analyses on Solibri Model Checker

3. Results and discussion

The quality assurance of the models should be a major concern of BIM, since the first steps in the project till the elaboration of basic 3D models. These models contain all the information necessary for the preparation of models of the following phases, including 4D, 5D and 6D, therefore the quality of these analyses depends on the quality of the basic model.

In countries where the BIM is more developed or has a high maturity state, there are already regulations so errors like these should be minimized, is the case of Denmark, Finland, Australia, UK, Norway, Singapore and the USA. The existing rules generally begin by appealing more to the sense of responsibility and in secondary way for the technical issues.

The expected results of this investigation will be, a creation of a list of rules that any contractor, when will extract the quantities to make the budget, may verify if the model sent by the designers/consulters is correct. This procedure also can be done by the designers themselves to check if their own model is correct.

4. Final Remarks

In Portugal, BIM, is taking its first steps. Companies like ndBIM Virtual Building are facing the beginning of this methodology/technology and its acceptance by the market.

Is very important that these cases of study be held in conjunction with students from local universities in order to develop competencies and information exchange, as is the case in this investigation that seeks to build competencies in the area of quality assurance with this collaboration.

This case study is intended to help the research in this area, applied to the reality of our country. Don't have the purpose to solve the problem but instead give a boost to new researches in this area.

5. Acknowledgments

A special thanks to my advisors, João Pedro Couto from University of Minho and António Ruivo Meireles from ndBIM Virtual Building, also to the employees of company ndBIM Virtual Building in particular Joana Cunha Fernandes and to the Solibri company.

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Improving MEP planning using BIM tools

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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, carried out in partnership with the company EFACEC.

It is a fact that BIM brought many benefits to the construction industry, and with it, engineers are now capable of making better projects with a lower cost in less time. Now, project leaders can coordinate and manage any project more efficiently and increase productivity. However, there is still is a gap of productivity, when we talk about BIM on Mechanical, Electrical, and Plumbing (MEP) projects.

MEP systems are the active systems of a building that temper the building environment, distribute electric energy, allow communication, enable critical manufacturing process, provide water and dispose of waste [1].

MEP related works, such as coordination and management, can be very tricky and challenging to accomplish due to the complexity of this kind of projects, especially when we are talking about big projects such as hospitals, health centers or shopping centers. MEP systems can represent up to 60 percent of the total building cost [2].

A major source of the mistakes and delays in building construction can be attributed to poorly coordinated design

documents. In the Fifth Annual FMI/CMAA Survey of Owners – a 2004 survey conducted by FMI Corporation and the Construction Management Association of America (CMAA) – 70% of the owners said they are seeing a decline in the quality of design documentation. For firms with slim profit margins, any rework costs exacerbate the bottom line – and MEP profit margins are notoriously slim (from 5% to 15% depending on the type of project) [3]. Another study conducted by Sir John Egan in USA, Scandinavia and UK shows that, up to 30% of construction is rework, labour is used at only 40-60% of potential efficiency and at least 10% of materials are wasted [4].

If in a not too far past, we used 2D drawings to coordinate, manage and plan MEP projects, in the present these processes can be done, using BIM technology. This methodology can be helpful and can improve the planning process, optimizing cost and time. Recently with the technological advancement and prevalence of building information modeling (BIM) and 3D modeling in the architectural, engineering, and construction (AEC) industries, new opportunities will emerge improving scheduling processes. By combining the built-in intelligence of BIM with previous research efforts we can further advance the automation of schedules [5].

When we are in a BIM environment and we talk about time, we are entering in another dimension of BIM, the 4D (3D + time). The 4D simulation, which is the sequencing of the different stages of the construction, can help managers make better decisions or workarounds more efficiently, comparing various possibilities of embracing the work, but it will also help in managing spaces, keeping schedules updated and improving communication between the different participants in the project.

In the point of view of a BIM manager the 3D model is nothing more then a visual data base that can be managed to get to fulfill reports and to track the construction status. This is why the "I" of BIM is so important. Having in mind the last sentence, in this thesis the main goal is to find one workflow, between different software, that can increase productivity when managing MEP projects.

2. Materials and method

2.1 Materials and method

The way found to accomplish the proposed goal was in the form of a case study, manipulating a 3D model in a critical way trying different approaches to the scheduling, simulating changes to the construction during the course of the construction and analyzing the effects. The software used were Autodesk Revit, Autodesk Navisworks, Microsoft Excel and Microsoft Project. Various workflows between the different software were tested in order to optimize the process of creation of a 4D simulation. This was an iterative process, where at the end of each iteration, the workflow was analyzed in a critical way and if any lack of productivity was found, that would be the start point for the next iteration.

2.2. Case study description

In the first stage, the model provided by the Engineer Francisco Reis (EFACEC), was imported to Navisworks and analyzed using the visualization tools of the software in order to get the first approach to the construction scheduling. After this stage, the different tasks were defined in MS Project and imported to the timeline tool of Navisworks. In the third stage, sets were created in Navisworks to attach with the corresponding task previously defined on MS Project, in order to get the 4D simulation. In this stage, the first gap of productivity was detected, because the creation of sets consumed too much time. Because Navisworks offers the capability to auto-attach sets and tasks, this workflow was revised and a unique code named, Phase_ID, was created. This code is the identification of each task and because the sets have the same name of the code utilizing simple connection rules the attachment between sets and tasks can be done automatically.

This workflow is good enough when we are in the public tender stage, but if we win the construction, many changes have to be made, and a good workflow has to respond efficiently, so it has to permit changes to the model that will not be too time consuming, and this workflow doesn't provide this capability. In this stage, the second lack of productivity was identified. In order to respond to this situation, in next iteration instead of creating set selection, search selection was created. The search selection is always searching the property that it was made for, and it updates automatically every time that the property is changed. Having this in mind in the next iteration, changes were made, not only in Navisworks, but also in the Revit model. In the Revit model a shared parameter was created and named Phase_ID and it was grouped under the Phasing tab. The Phase_ID parameter has to be filed with the corresponding Phase_ID unique code of the MS Project task. After this process is done, in Navisworks a search selection was created having as criteria the Phase_ID parameter and at this point the creation of a 4D simulation can be created almost automatically.

3. Results and Discussion

This work is still in progress and it has been an iterative process, where various workflows have been tested. In – figure

1 we can see one example of one workflow, of the first stages. Sometimes from iteration to iteration the evolution is extremely small but the results are considerable. It also opened doors to other fields of BIM management. Working in a similar way as described in - section 2.2, utilizing shared parameters, search selection and codes such as, Phase_ID code, we are able to track equipment, to see the construction status and fulfill reports automatically.

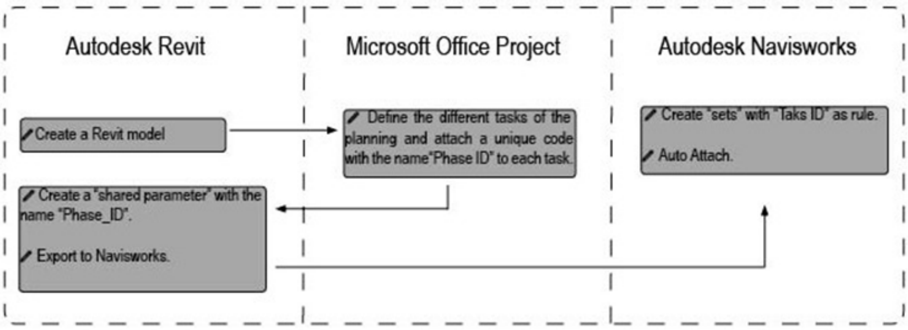

Figure 1- Workflow example

4. CONCLUSIONS

BIM methodologies are changing the AEC industry. It has introduced the collaborative work, where all the construction

participants work together. The information is vital and the way we manage it can be the secret to increasing productivity and achieving goals such as reducing costs, times and managing spaces. In this document, one workflow was presented, and using the same philosophy of work, connecting different software and managing data, projects can be better, cleaner, sustainable and environmental friendly.

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Building Information Models for Architectural Design: an intuitive design methodology

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1. Introduction

The digital era has brought changes in the architectural conceptual process. Design computing has expanded in scope beyond building descriptive system to now include analyses, simulation, parametric generation and fabrication. Early conceptual stages are extremely important in determining the success and impact of the architectural project. However, digital tools to support these stages of the design process need to be further developed.

3D virtual models first appeared in architecture as representational tools responding mainly to aesthetical concerns. At the same time structural and construction orientated software was developing mainly with production concerns integrating within a single software, construction management, analyses, simulations, building life-cycle management and a database of information incorporated within parametric 3D models, laying the foundations for more collaborative and effective models, the building information models [1]. These two trends that developed separately are now "giving way to a still emerging area of overlapping concerns" [2].

BIM (Building Information Modelling) benefits in the AECO (Architecture, Engineering, Construction and Operations) industry have been very well charted. This paper does not seek to do an evaluation on efficiency gains or the advantages of adopting BIM, but to develop a design methodology using BIM software tools to bring together design software and construction software by creating an intuitive design methodology that integrates the conceptual process, using a flexible and intuitive model, with a constructive, production orientated BIM model. The aim is to introduce constructive and efficiency orientated parameters during the conceptual phase and comprehend its limitations and new potentialities.

Autodesk Revit, for example, has new conceptual design tools and adaptive components that allow a new level of relations between conceptual and constructive design. New applications now created allow visual programming and scripting inside Revit's environment. These applications enhance its parametric capabilities for generative design and algorithm design.

Parametric design is an associative geometry that is formed by equations and interdependencies between objects. The model thus behaves accordingly to rules and requirements established by the designer allowing it to respond with instant solutions to any change made and giving multiple outcomes so that the designer is able to pick up a solution out of many variations.

Parameterization allows the designer to create its own rules for formal experimentation. In parametric and generative

modeling the selection criterion for the optimal configuration may be technical or aesthetic [3].

Using BIM's parametric design the model will report for documentation, manufacturing and constructive details, evaluating and giving the architect's feedback to further enhance the design process.

Because of BIM's great collaborative features there was a major change in the traditional project delivery process. All parties involved in the project are integrated in the design a lot earlier in the process, being able to find errors and solve conflicts during the initial stages of the design.

These collaborative efforts influence the architectural design in a positive way when notions of creativity and innovation arise from performance and cost-efficiency concerns.

There are different types of models, some better suited for constructive matters or others for representational or aesthetical matters. BIM is a platform of convergence where all different AECO concerns are brought together.

The management of all this data brings architects a lot closer to the construction process and to all collaboration related benefits.

2. Materials and Methods

This paper focuses on the architectural design process and explores BIM's potentiality to create intuitive and creative virtual models maintaining all of BIM's efficiency features. The selected software for a practical application was Revit from Autodesk.

The experimentation model used for a practical application is a canopy for a public space that is parameterized to adapt according to site elevations and according to public use, thus being able to experiment alternate configurations as different uses are tested. The model explores BIM's parametric design inside a conceptual design environment that stays linked to a constructive design environment and constantly updates any change made in the conceptual model.

In this experiment the parametric model explores mainly reporting parameters that inform the designer of the consequences of any change made to the model, informing of floor areas, slope or ceiling heights as other relevant technical information. Parameters are assigned to measure panel deflexions and size variations so that a more cost-effective study may be achieved. Other parameters to aid manufacturing and constructive purposes were also addressed.

The design process is disturbed by the imposition of too much information too early in the design process. In a conceptual phase of the design process too much information may induce the architect to make premature decisions. At an early stage of the design process there is still a high degree of uncertainty, the architect is still defining an idea and experimenting different solutions and raising new questions [4]. He shouldn't be picking up things out of a pre-formatted library, instead, he should be thinking of space and volumes, openings and passages, planes, solids and voids.

Traditional methods tend to integrate measurable criteria only in advanced stages of the design process. The design criteria in the early stages of the design process usually relies only on the insights of the designer [5] in opposition to a BIM collaborative process where the influence of an early integrated process will have impacts on the final design solution. The authors critic rely on the ability of creating a collaborative design process where the designer may benefit from insights of all disciplines at an early stage but still have the flexibility that is inherent at this stage of the design.

The ultimate goal is to create a methodology where the designer may create flexible and intuitive BIM models on a first stage and introduce different types of parameters with production, efficiency and manufacturing orientated concerns. This will lead to understanding how the input of efficiency concerns in the early stages of the design may influence the design process by limiting or creating new possibilities for creativity.

3. Parametric Modeling for intuitive architecture

For this experiment were created only two types of parametric panels to measure each panel deflexion and exposure. The values are sorted by colour, allowing the designer to measure the consequences of his actions as he manipulates the shape of the canopy (Figure 1).

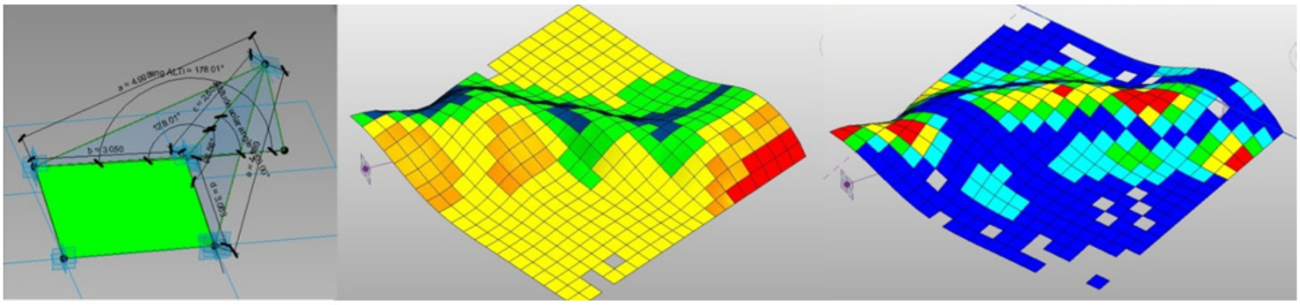

Figure 1 – Parametric reporting panels

This first analyses phase allowed the free modelling, testing and raising of new questions and the later decision of which factors would drive the shape and behaviour of the panels. Defining how the panels would deform, open or close according to the intended sun exposure.

The intuitiveness that was sought after can be achieved in BIM systems when the parameters are being used only to inform the architect and giving him the data and tools necessary to make more creative and efficient decisions, instead of imposing constraints or premature decisions.

4. Results and discussion

This paper demonstrates that BIM is ready for conceptual and schematic design and that it is a tool with great benefits for architects.

As technical and aesthetical matters are coming closer together in the architectural practice new possibilities arise to generate new creative and effective solutions.

Instead of using parameters for form and aesthetic explorations, intuitive and reporting parameters can be used to allow flexibility and creativity during the architectural design process. Efficiency orientated parameters in the conceptual design phase anticipate technical concerns increasing the architect's control over the design's final outcome.

BIM tools with its performance-based criteria may influence the architectural design process in a positive or a negative way. The architect needs to understand what disturbs and what enhances the design process.

5. Conclusions

Intuitive design in BIM opens the way for architects to really grasp the potentialities of BIM in the ongoing switch from CAD to BIM encircling all of its effectiveness gains with its the creative capabilities.

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Rethinking the Project Development Process through Use of BIM

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1. Introduction

Information is a crucial factor for building projects. IT systems have been developing to help project participants access more accurate and updated information. The most well-known and functional IT product presently is Building Information Modelling. BIM is not just a 3D virtual representation of building, but is a process by which a digital representation of the physical and functional characteristics of a facility are built, analysed, documented, and assessed virtually, then revised iteratively until the optimal model is obtained [1]. However, in regard to the linear, uncoordinated and highly variable traditional processes, there is ambiguity how BIM can be consistently utilised during whole project life cycle and whether traditional processes and project delivery methods are able to fully benefit from BIM. This research aims at (1) rethinking the current life cycle of building projects through implementation of BIM, (2) exploring how BIM can overcome problems within the traditional process management, and (3) analysing the existing project delivery methods to find the most appropriate method for development of BIM based projects.

2. BIM as project development process in a building life cycle

BIM is not just a tool or a solution [2] but requires new processes and new channels of communication [3]. The traditional building life cycle has the highest workload when the construction documentation is made while in this point changes cannot be made without considerable negative impact on the costs. Preferred BIM approach forces a lot of decisions to be made in the early design phase where the cost and risk of change is lower. Moreover, BIM process greatly benefits from concurrent engineering (CE) management principles. The purpose of CE is to modify the sequential waterfall model into an iterative and integrated design mode. These indicate a need for involvement of specified expertise in the project at earlier stages to detect errors before they become high cost impact. Overall, BIM aims to foster optimal collaborations between project stakeholders through the life cycle of a facility to insert, extract, update or modify information [1]. By using BIM, project participants can have the potential of coming closer to start an accurate and multi-disciplinary collaboration. BIM's major objective therefore is development of a new and modern process in order to have more time and cost effective production process and facility management by means of software options. Other changes caused by BIM implementation are explained below in detail:

2.1 Visualisation and its impact on communication, collaboration and planning:

The capability of visualisation in BIM facilitates decision making process on the aesthetics and functionality of the space. It profoundly improves communication and collaboration amongst the project members whereas traditionally the primary causes of the construction's poor performance is due to ineffective communication practices [4]. Visualisation promotes planning and sequencing the components and tasks by first checking them in model prior to production and then following up the actual construction status through updated installation dates of structures and systems [5].

2.2 3D Coordination and its Impact on Workflow and Productivity:

Coordination efforts of construction manager and specialty contractors before construction via BIM implementation correspond with reduction of design errors and better understanding of the project. Hence, number of requests for information and change orders during the construction is reduced which improves workflow and productivity [6].

2.3 Digital Data Storage and its Impact on Data Recapture:

The loss of data in traditional paper based processes is a problem.

BIM collaborative environment mitigates this risk by storing information digitally and making the data easy readable to all participants. Thus, contrary to traditional processes that fail in recapturing all information, BIM stores the data accurately during the building life cycle [5].

2.4 Time Estimation and its Impact on Project Planning and Monitoring:

The schedule of the anticipated construction progress can be integrated into the building information model. Prior to construction, time estimation optimises the logistical aspects; various alternative solutions of executing the construction can be simulated and weighted against each other to find the most beneficial solution [5]. It additionally provides considerable insight into the project and facilitates early detection of planning errors instead of realising them later on in the construction phase and having to resolve problems on site which can be very costly. During construction stage, this method graphically visualises the project schedule and enables the users to plan and monitor the construction activities, site utilisation, space coordination and safety management principles at any point in time. Furthermore, field data acquisition systems such as Radio Frequency Identification can be linked to the 4D BIM. RFID is tagged to the trades' protective hats to control the manpower and their position regarding the project schedule. Thus, the daily activities of crews will be monitored to find whether their productivity and manpower are sufficient for planned schedule.

2.5 Cost Estimation (5D) and its Impact on Project Control:

This capability enables BIM users to generate accurate and reliable cost estimates by automatic quantity take off from the building model, receive a faster cost feedback on changes in design phase and better understand the financial implications of design decisions [7]. It can be used as a foundation early on in the project for the contractor to control costs and optimise the quality requirement based on the budget.

2.6 Accurate Information and its Impact on Prefabrication:

One of the major prerequisites for prefabrication method is accurate design and erection information. Integration of BIM and prefabrication method enhances the information exchange of the products between project members and significantly it is used to virtually coordinate the location and routing of the products.

2.7 Record Model and its Impact on Information Management:

The majority of building information traditionally has been stored as paper documents, supplied to facility managers after a building was in operation [3]. As a result, much valuable data associated with the design, construction and operation of a facility is lost during the building life span [8]. Record model can have a crucial impact on information management of construction projects and building life cycle [9]. The model includes important information in terms of manufacturer specifications and maintenance instructions for building and installation components that help the facility managers to find information easier. Moreover, not only different analyses can be made to examine whether the building and its systems work properly [5], but also management of security and safety information thereby is facilitated. Nonetheless, the interoperability of the record model with various applications [10] and the owner's reluctance towards allocating adequate budget to train employees, update, and maintain the model can be problematic.

3. Delivery method for BIM

Regarding traditional procurement routes and forms can be the biggest hindrance to a proper BIM implementation, it is important to adopt appropriate project delivery methods when aiming to rethink the project development process through use of BIM. The AEC industries have traditionally assimilated fragmented approaches when it comes to project procurement. Current dominant project delivery processes are primarily dependent on paper-based modes of communication. However, there is an urgent need for better integration of project teams and collaboration between all parties. It is also required to have a new way of dealing with information and moving from the document paradigm to the Project Integrated Database paradigm.

Analyses of delivery process method shows the design-build, IPD and other forms of collaborative delivery methods enable better opportunities for the client to benefit from BIM adoption due to (1) all prime players are involved from the earliest practical moment, (2) the design mostly is performed in-house [5] and (3) entire project team is equally (or similarly) incentivised to achieve the same set of goals [11]. Nevertheless, there are some pitfalls associated with collaborative methods such as inability to manage the project teams, lack of competitive bids and disregarding client's needs. Therefore, it is still needed to find alternative BIM based approaches to deliver a facility that creates a win-win situation for all stakeholders [12] and addresses all found challenges in existing methods.

4. Conclusion

Traditional development process in building projects is inefficient and faced many challenges. The future of the industry lies in the use of technology and BIM is expected to build this future. The introduction of BIM into life cycle of the projects requires fundamental changes in traditional development processes. Most importantly, BIM aims to focus the bulk of workload in early design phase when cost of any change is lower and use the CE concept to modify sequential waterfall model into an integrated design model. In general, BIM is able to revolutionise traditional development process and overcome related challenges in order to have more time and cost effective processes during building life cycle. To do so, BIM primarily requires enhanced integration of project teams and collaboration between all parties. Hence, collaborative delivery methods such as IPD and DB compared to linear methods like DBB are more appropriate to optimise BIM based projects. There are however some challenges implying a need for development of new methods and clear guidelines to create a win-win situation for all stakeholders.

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BIMAppBuilder: A Framework Wrapping Selected BIM Functionality for Facility Management Applications

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1. Introduction

As more and more buildings are constructed, it can be expected that building information model (BIM) technology will play a central role in the management of a building's all kinds of information for its entire life cycle. Meanwhile, there is an increasing number of software applications developed for facility management (FM) of a building. Theoretically, these applications should use BIM's functionality such as materials quantity takeoff calculations, as well as the base geometry data representing their individual buildings, in order to provide customized functionalities for their FM users. In other words, not only data but functions provided by a BIM tool in the design and construction (D&C) phases should be able to be reused by FM applications. However, the NIST report has demonstrated that inadequate interoperability does exist between software in different phases of a capital facility project [1]. For example, if a maintenance worker performs regular inspection and finds inconsistences between a real-world building element and the virtual one in a BIM tool, current FM applications cannot issue database update commands against the BIM tool, because there is no interfacing program available to carry out the commands. Additionally, for the function side, FM applications often provide limited functions regarding spatial analysis and visualization, which can be easily provided by a BIM tool. In summary, integration of BIM into FM applications is needed, especially for BIM's functionality.

Model-driven architecture (MDA) technology is a software development methodology. It relies on Unified Modeling Language (UML) as a template to describe a software application. Designers can use UML to design a software model, and MDA will transform the model into the codes that can be used to build the real application. Both BIM and MDA are not new technologies. However, no research exists to explore applying MDA to BIM. In this study, a simple FM application for calculating floor areas of a transit station was developed to validate our proposed approach, i.e., BIMAppBuilder. This application was automatically generated by using BIMAppBuilder, with a few customization codes, in order to pass the compilation process to become a real workable application. The application's model consisted of two parts: one was from its BIM file and another was designed in the traditional UML way to fulfill requirements of the application. The Revit2UML tool (one module of BIMAppBuilder) was utilized to help the model transformation process from Revit to Umbrello (a UML drafting tool). The Parser tool (one module of BIMAppBuilder) was utilized to help complete the static code-generation aspect of the application model, while the Code Maker tool (one module of BIMAppBuilder) was for the dynamic aspect based on UML sequence diagrams designed. The Project Builder tool (one module of BIMAppBuilder) was utilized to synthesize all the codes generated and create a Visual Studio project for a Revit Add-in program. Therefore, BIMAppBuilder includes the above four tools, and a socket-based software service tool, Revit Remote Service, is being developed to further simplify the efforts of developing a BIM-related software service. It can be expected that most of the BIM-related applications can be automatically generated by using BIMAppBuilder, with a few modifications on the source codes. A distributed software service for BIM data retrieval and update can be realized by using the Revit Remote Service. Since BIM can be applied in each phase of a building's life cycle, the proposed approach may help creation of these applications efficiently and effectively, especially for the O&M phase of a building.

2. THE METHOD

Design and drawing guidelines for handling building elements inside Revit have been defined in order to make the BIM file readable by the Revit2UML tool. Figure 1 shows the Revit BIM model of a real transit station in Taipei, and Figure 2 shows one part of the UML model generated by the tool for this station. Figure 3 shows the overview of BIMAppBuilder. Figure 4 shows another application generated to assist facility managers in quick identification of broken pipes in a building.

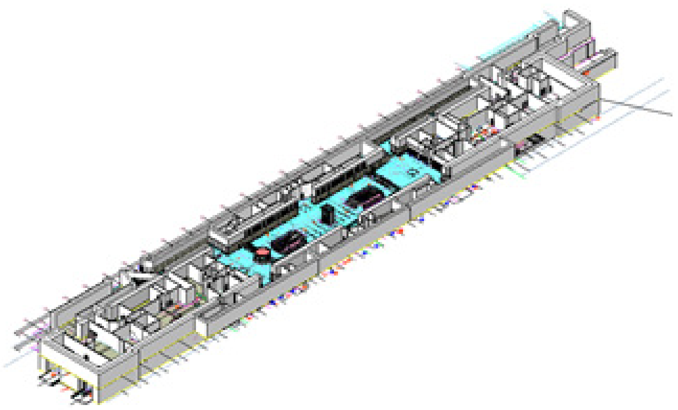

Figure 1 – BIM for a transit station in Revit

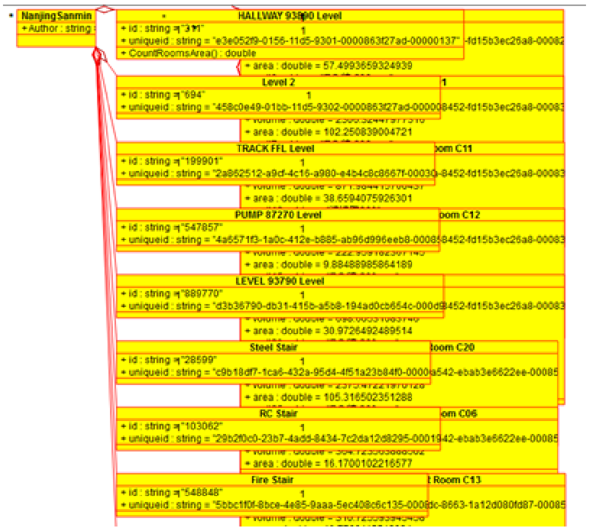

Figure 2 - Part of the UML model generated for the station

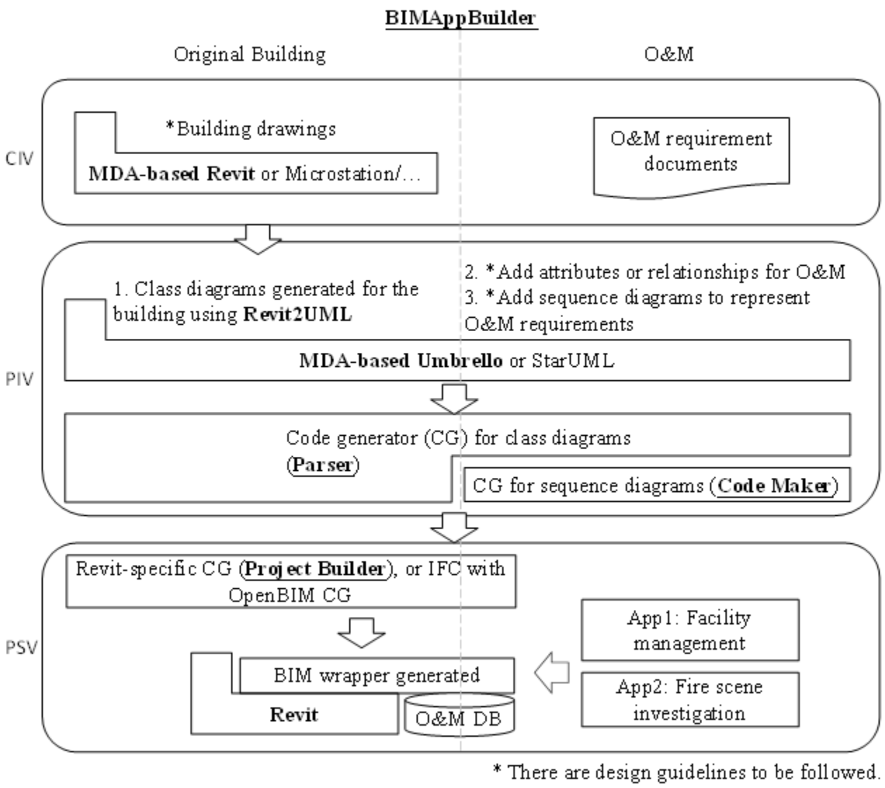

Figure 3 – Overview of BIMAppBuilder

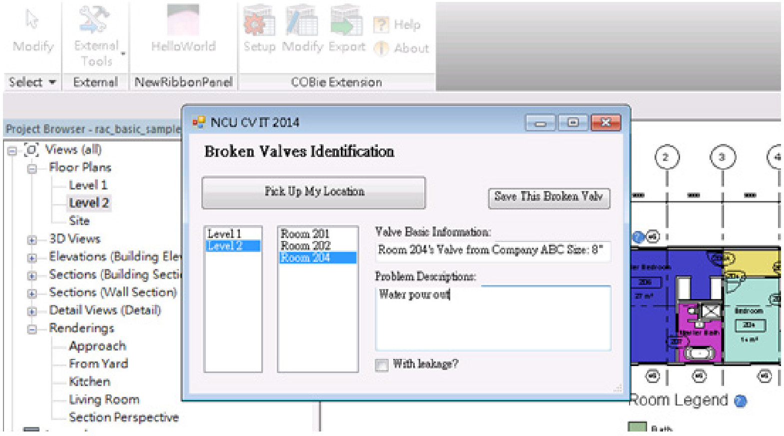

Figure 4 – The broken valves identification program generated by BIMAppBuilder

3. Conclusions

This research proposed a software framework, called BIMAppBuilder, which is based on MDA and can help integration of BIM. Undoubtedly, BIM can be regarded as a comprehensive data source to fulfill the information needs in the D&C phases. However, such the situation cannot be seen in the current FM applications. In FM, there are additional requirements that can characterize BIM usage as the base data source, which means the BIM data should not be changed frequently. If the original BIM technology is utilized, writing codes to integrate BIM is difficult and time-consuming in the FM applications, because BIM wants to keep the maximal flexibility so that every building element, regardless of its possibility to be changed, is regarded as an object.

With use of MDA, transformation of BIM can be automatically performed so that the same concept of a building element can be transformed from the meta-class level to the class level, which provides more space to write FM-specific codes inside the classes generated. Application developers in FM can now have a more direct mapping between the actual building and the virtual one, which provides a more intuitive way to think about their building. Currently, BIMAppBuilder only includes the transformation tool for the Revit environment, and the codes generated can be only edited and compiled in the Visual Studio IDE. Future development work includes the portability issue to develop for the IFC with OpenBIM, Microstation and Tekla environments. Common access codes to the BIM data can be provided by BIMAppBuilder as well in the future. Because owners or facility managers usually have the portfolio thinking, i.e., a set of building to be managed, BIMAppBuilder should aim at helping development of similar software applications for managing the assets in a more consistent way. Other application domains of FM should be explored by using BIMAppBuilder, to further validate that the proposed MDA-based approach is useful.

4. Acknowledgements

The research was supported in part by Ministry of Science and Technology (MOST) of Taiwan under Grant MOST 103-3113-E-008-002. The authors are grateful to the anonymous reviewers for their valuable suggestions to improve this paper.

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The Future of BIM- the Merge of BIM & Project Management

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BIM Angels

1. Introduction

As the etymology of the word suggests (from Greek chief builder), the architect is a person who plans, designs and overseas the construction of buildings, i.e. the leader that manages the whole process of creating facilities of human occupancy or use.

Yet, somehow along the process of industrialization and advancing the technology the architect has slowly been giving up its leading role in the construction process. We were made to believe that being technical and being creative cannot be integrated. The result we face is arguable execution; poor cost control and design intentions not being followed.

Somewhere along the line BIM has been introduced to solve the issues we face on a daily basis. BIM is about going back to our core identity: managing the process of creation and delivering high quality buildings with the tools at hand (be it a pencil or a computer).

However, one of the main challenges that need to be overcome, according to my professional experience, is the misconception of looking at BIM and project management as two separate activities. BIM is just a more technologically advanced way of doing project management. By job description, the project manager is the person responsible for the programme, budget, resources, choice of procurement process, deliverables. The BIM manager has the same responsibilities as the project manager but in a more integrated way – they cover the entire facility life cycle, from planning through execution to facility management. A change in looking at the design process and higher level of skills is required.

2. Materials and method

I would like to present the everyday challenges we encounter in order to deliver a BIM project with real life examples.

However, I will keep the information as generic as possible for confidentiality reasons.

2.1. Case study 1: Mixed use development (residential + retail)

Approach: The project started as a client driven first test for BIM implementation. The project managers did not have the relevant BIM expertise, so they relied on external BIM consultants with whom they communicated all way through the process.

Strengths: (i) flat structure and shared responsibilities throughout the team; (ii) the BIM experts were qualified and experienced architects and the communication with the project managers was productive; (iii) a database was created according to company's standards; and (iv) internal training was provided and knowledge shared

Weaknesses: (i) the project managers were not able to supervise the intelligence built into the model for the lack of hands-on experience on the software used; (ii) the traditional method was enforced back in terms of resources /staffing/ half-way through the project, and such unnecessary expansion of the team resulted in the coordination issues, so more time was spent to correct errors than for the actual design process; and (iii) the time for creation of the data base was not provided for in the initial project programme.

Results: The initial setting up (based on BIM management) went smoothly, on time and within the budget. The communication with the client was improved and their trust in the information being reliable was gained. So the client gave us an extra time to set up a well organized and user-friendly database which could be used on future projects. Also, the client's trust lead to a new project being assigned. Nevertheless, the use of the traditional methods half-way through the project had its adverse consequences for the due and timely completion of the entire project.

2.2. Case study 2: Mixed use development (residential + retail)

Approach: A similar project as in the first case study with the same client and the same requirements. The traditional hierarchical management structure was used. The newly appointed external BIM leaders were not with the relevant architectural experience.

Strengths: (i) created and approved by the client database; (ii) main part of the team already trained and experienced with the project typology and the client; (iii) client's trust gained (iv) lessons learnt from the first project; and (v) project challenges and deliverables were predictable.

Weaknesses: (i) inability of managers to supervise and check the quality of models; (ii) lack of communication within the team and with the consultants; (iii) lack of training; (iv) no clear rules and the Executive plan was not followed; (v) every task was done for meeting the deadline without considering the impact on future deliverables; (vi) the BIM leaders were not architects and lacking the ability to be part of the decision-making process in the critical early stages of the project; (vii) unwillingness to use the database already created; (viii) team increased out of proportion.

Results: Although with a very good foundation for being a successful project, the prevail of weaknesses over strengths and the lack on management side to acknowledge them in the critical early stages, lead to a lot of abortive work, deadlines hardly met and the budget was overrun. The information provided to the client was not reliable enough. The client's trust was lost.

2.3. Case study 3: Commercial development (office building)

Approach: A client driven BIM project with all the consultants involved experienced in BIM projects. Training and workshops were considered as a part of the programme. The latest version of the relevant BIM software was provided. BIM leaders with high level of expertise both in software and architecture were appointed as team members.

Strengths: (i) BIM leaders were a dream team of experts; (ii) latest software was used to support the process; (iii) small qualified team within a newly launched company with presumably flexible structure; and (iv) internal training was provided, at least in the first phase of the project

Weaknesses: (i) too many managers who refused to understand the process and get involved; (ii) a traditional hierarchical structure; (iii) a complete lack of communication; (iv) an assumption that the software can resolve design issues; (v) none of the experts were involved in the design and decision-making process; (v) inexperienced people neither in software or architecture were taken on board with no training and /or supervision; (vi) no clear instructions were given; (vii) the BIM manager was perceived as a person who should fix software problems.

Results: Perfectly planned but badly implemented. Simple tasks were repeatedly done due to the lack of communication. The main advantage of the BIM creating intelligent models was not introduced because it was deemed superfluous. The models were used as basic CGIs only, hence the need for Value Engineering. The project ran over budget, the programme was not coordinated with deliverables. The quality of deliverables was arguable if not poor.

3. Results and Discussion

The managers' inability to keep up with software requirements was an issue in the first scenario but the project was started on a really good platform. The expertise-lead process and flat structure helped to well programme the deliverables. Use of a few but skilful people resulted in gaining the client's trust.

However, going back to the traditional management lead to loss of client's confidence and slowed down the process. Similar was the result from the managers' underestimation of necessary training and their failure to understand how BIM works (as in the second scenario).

The lack of hands-on experience and supervision by the managers over the actual intelligence in the model and participation in the production line resulted in important early decisions being taken by inexperienced and unqualified staff.

Also critical was the lack of continuity and inability or unwillingness to use the database already created as it lead to a waste of precious time for design and coordination and doing things all over again.

4. Conclusions

As Einstein puts it, "Insanity is doing the same thing over and over again and expecting different results."

The moment we realize and accept the fact that we should manage our projects with all the new technologies if needed, focus on creating the perfect team and challenge them to perform to the best of their professional skills, the trust in our role in the building industry will return.

BIM is not only about managing data and delivering building facilities to higher standard, BIM is also about managing people. Architects, by default and by professional expertise, are or should be the right people to lead the process and they have to keep up with the pace introduced by technology if not advancing it. The merge of BIM and project management might be a smart way forward.

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Construction Data Mining - The reuse of BIM Information in decision-making

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ndBIM Virtual Building

1. Introduction

First, it is crucial to define the data mining term, which is defined by Geoffrey Holmes and Sally Cunningham as "a technique that explores a rich, relatively unstructured set of data and retrieves from it unusual patterns, unexpected regularities, implicit information, etc." [3] This definition describes exactly why it can be so powerful to construction companies. It transforms the simple data into decision-making supportive information by detecting unusual aspects that will be useful in the identification of what is working and what is not. It is much easier to become a more efficient company when you really know what is going on.

Everyday construction firms generate a big amount of data during their projects, which they store in their data systems throughout time, such as labor, machinery, materials, among others, related with the design, estimate, schedule, quality, etc. [1] This paper introduces two fundamental queries: the importance and the transparency of BIM information and the fact that the construction companies do not reuse any data to support their decision-making process.

It is increasingly apparent that Building Information Modelling (BIM) offers a vast amount of benefits to the construction industry, namely clash detection, better coordination, 4D scheduling, among many others but, in fact, the major benefit of BIM is the powerful information that is created along the process. Many companies are already adopting this technology but still do not reuse the information that results from it: productivities, task durations, costs, subcontractor information, and so on.

This methodology arises in a way that enables construction companies to start using all the stored construction data in order to support and enhance the decision-making tasks. As the project develops and changes are being made, all the information is updated and coordinated at real time while the relationships between the several information resources are expressed as a whole. [2]

The amount of information which results from the process, not only from the 3D design and coordination phase but also from the construction management stage when the project is planned and then monitored by the BIM platforms, must be manipulated to allow managers to see the kind of information they need at each moment. If the collected information is not standardized then it becomes useless and it is not possible to make any statistic study with it, remaining unsafe to use in future projects. Thus, it is important before any usage to categorize it by cost, task, subcontractor, etc.

It is also proposed a method which allies not only the benefits of BIM but also the data mining tools that could make the information valuable for managers to make better decisions.

2. Materials and method

The first step for reusing the construction information is to define a standard procedure for nomenclature and organization of the data that is extracted from the budgeting, scheduling and monitoring processes. The main procedure is represented in Figure 1.

As shown in Figure 1, managers can extract real information from management BIM software not only during (actual information) but also at the end of each project (historical information), such as labor productivities and consumptions, task durations, quantities, costs, and so on. There are two parallel paths in this procedure: actual and historical. In the first case, the information is extracted regularly during the project and then analyzed and presented on a dashboard. On the other, it is extracted from the several systems and then standardized, analyzed and stored.

The dashboards, both actual and historical, are simply a way of representing the construction and BIM data, as it is visible on Figure 2. This panels allows managers, technicians and CEOs to realize if the project is actually going according to plan (and its causes, if not) and then support their decisions

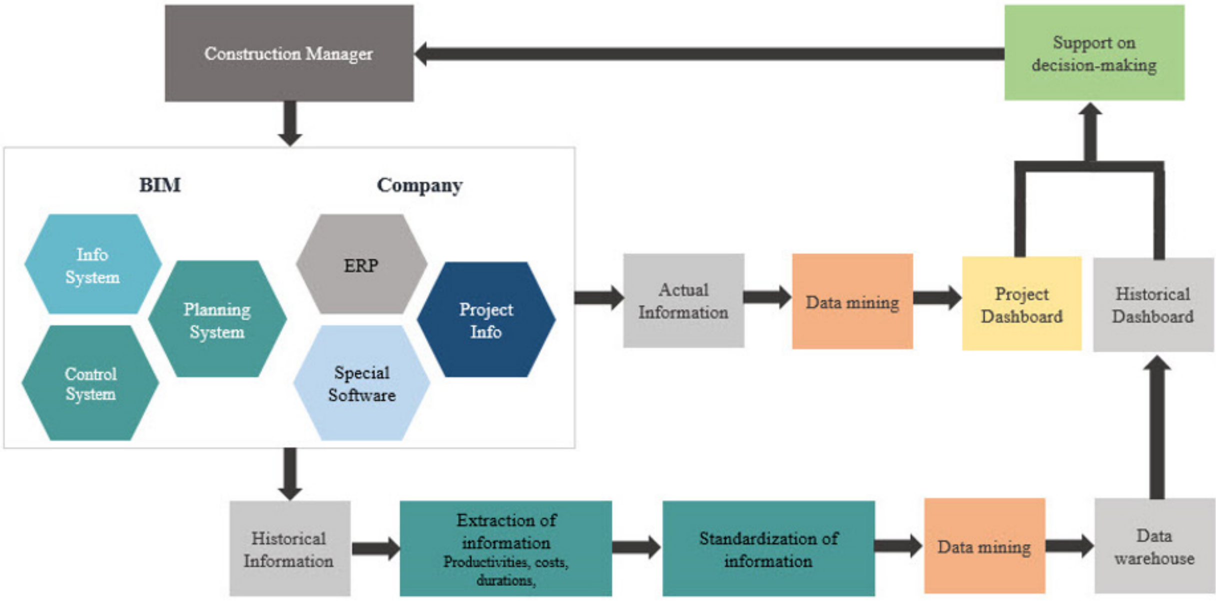

Figure 1 – Reuse of Construction information, modified and adapted from [2]

on the facts that are presented on it.

What makes this procedure so unique and effective is the standardization of data presented on it. This is because the standardization is the keystone towards data manipulation, which must be correctly set in the procedure due to the fact that nomenclature, frequency of extraction and storing destination enable the data mining tools to filter and operate the information. There are infinite standards for information organization and structure and, in the BIM area, Omniclass and COBie, while different, are two of the most used. What this method argues is that you most standardize your data but it does not matter how you do it, you can do it with any standard you like that suits your projects or you may even create one for yourself.

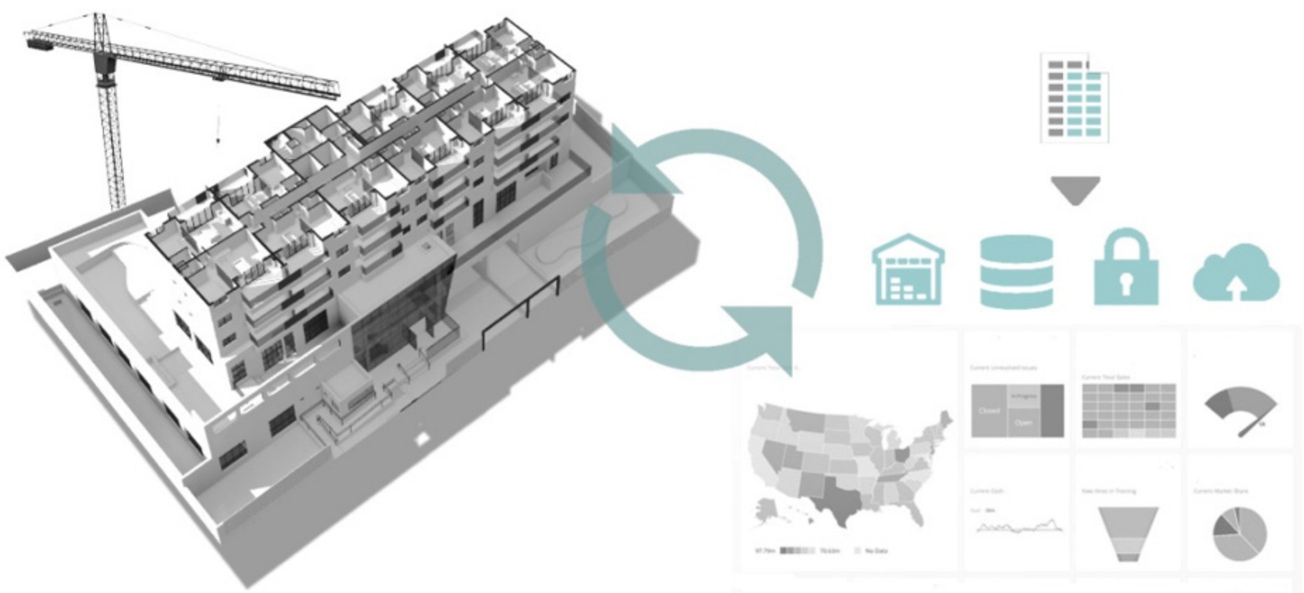

Figure 2 – BIM Model Collaboration with the Dashboard

There are many solutions for dashboards and the best way to evaluate their features is to develop a benchmarking study and score the several functionalities. The key requirements the platform must meet are: Excel import, preferably in the cloud for automatic updates; basic analysis functions; statistical analysis; and graphical and regression analysis.

In addition, there are several types of dashboards. Although the most common is the web-based application, some of them are an application that remains physically on the equipment (PC, tablet and/or smartphone) and the dashboard may even be developed using Excel, but without the data interactivity animations (drill down, drop down, filtering).

3. Results and discussion

The information and values that outcome from the construction data mining are real and justified, because they are obtained from real productivities, durations, consumptions and many other items from past projects. In this way, it is much easier to identify problems (e.g., the task responsible for the project delay, the subcontractor that could not follow as predicted, etc.). Another big benefit of reusing construction data is to enable the creation of more accurate schedules and budgets, as the historical information is being updated at each project (actual information) and becoming more and more precise.

4. Conclusions

It is concluded that there is a substantial waste of information regarding the construction industry, which turns more evident by an accurate BIM implementation. The reuse of the information, if properly done, can lead to a greater efficiency in the management of information and resources of a project, in order to support the decision making process. The use of a dashboard enables the representation of this data, automatically updated, in an extremely visual way and also it can be shared with all the departments. However, it is important to follow a strict procedure of data reuse and to actually take advantage of the information generated, while the representation platform is just one of the means needed to achieve a higher end.

One of the greatest difficulties is to ensure that the process is followed by the participants and that the standardization is performed correctly, which allows companies to take real advantage of data mining processes. In order to gain reliable values, the data must be extracted at the same time and in the same manner, in every site. Thus, the key challenge is to assure that there is discipline in the process, setting strict procedures and assuring that these are followed.

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BIM-FM Implementation

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1. Introduction

Historically, the owners always chosen the most cost-effective construction solutions, this because the construction was considered the biggest expense. 'Studies conducted in several countries, for different types of buildings, show that the annual costs involved in the buildings operation and maintenance varies between 1% and 2% of its initial cost. This may seem small, but over the buildings life cycle gets to be equivalent to or above the cost of the construction' [1]. This mentality arises from the lack of knowledge of what means the life cycle of a building. In the figure below you can see that the construction is just one of the costs involved in the building whole life cost.

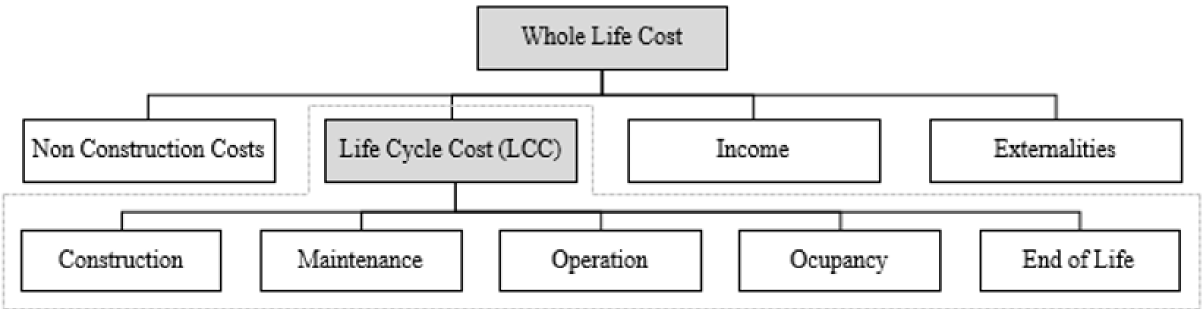

Figure 1 - Building Whole Life Cost [2]

Recently, the awareness of owners to the real costs has increased; they also consider the costs after construction. This change of mindset leads to some necessary technological developments in order to track the progress.

1.2. Building Information Modeling (BIM)

'Technology, coupled with owner demands for better, faster, less costly projects and processes that are more effective, is driving change in the design and construction industry' [3]. Thus, BIM arises as a solution to an aged industry and attached to old processes. The BIM concept is a sharing information method among the various stakeholders, which is based on a digital model of the building where all this information lies.

The Building Information Model is 'a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various user's needs can be extracted and analyses to generate information that can be used to make decisions and improve the process of delivering the facility' [4].

1.3. BIM-FM

Development of the technology for building management lead the facility manager role to comprise a wider range of disciplines, increasing the importance of a proper information administration. BIM methodology, being a collaborative tool allows accessibility to an updated information provided by all stakeholders.

Thus, in a very succinct way, the implementation of the BIM-FM methodology is the application of facilities management through the functionalities provided by the BIM model, such as the geometric model and the database containing all necessary information of all elements [5].

2. BIM-FM IMPLEMENTATION

2.1. Construction-Operations Building information exchange (COBie)

The COBie format is the international standard for the exchange of information about managed facility assets [6].

COBie's focus is on delivering the building information that is not geometric. Its purpose is to exchange information that is gathered during construction to be further passed on to a building's facility manager. This approach leads to a change in the way that information is gathered, representing an added value to the owner.

2.2. Model Integration

Frequently it is assumed that an As-built model should have a LOD500 (geometric and non-geometric) and some authors also affirm that, for FM, it should be used an As-built model, because it must contain the final changes made during the construction and all the data. This looks correct, but an FM model does not have the same requirements as a Construction model. So it should be used an As-built model, but an evolution of the model used for the Construction or Design phases.

In the Construction phase, is usually used a LOD300 (geometric) for the general buildings, because currently the requirements for construction do not demand high detailed models and it is enough for quantity takeoff, clash detection, scheduling and budgeting. In some cases, when pre-fabrication is used, it's necessary a higher LOD – LOD400/500 (geometric) – is necessary due to the level of precision and the detail that is demanded.

The Operation and Maintenance phase focus mostly on handling with the non-geometric data, so it´s correct to state that, for an FM model, the components doesn't need the same level of detail as the other phases. In fact, considering that most of all BIM-FM applications are Software as a Service (SaaS), the size of the model file is one of the most important points, when considering the LOD that should be used.

It is also important to consider that the As-built model is not the final model, since with FM the model is always updated with the last changes made during the OM phase, becoming an As-managed model. An As-managed model, do not have a higher LOD, since it does not have more information, it has an update for the current conditions [5].

Thus, since LOD definitions have both geometrical and non-geometrical aspects, but only the geometric requirements are specified, a new approach to LOD requirements could be adding the non-geometrical requirements as well.

3. Case Study

This case study is an existing building which does not have any type of BIM model or management system. For this implementation, it was decided to use ArchiCAD as the modeling software and ArchiFM.net as the BIM-FM solution. This type of information is critical to the development of the implementation plan, which is divided into 5 phases:

- Requirements Definition;
- Data Gathering;
- Modeling of the School Center according to the requirements definition;
- Integration with BIM-FM solution;
- Development of FM Database.

3.1. Requirements Definition

Defining the requirements is extremely important to establish the purpose of the model, in order to gather and model only the really necessary data. Introducing unnecessary information will make the process longer, besides it will make the model heavier. Based on a list of features required some FM softwares were tested and the natural choice was to use ArchiFM.net. One of the advantages is that it does not have a 3D viewer, since it take advantage of ArchiCAD there is no problem with the size of the model. Another important thing is that in the future the owner does not have to rely on the supplier to update the model since ArchiFM.net allows him to do it by himself. For this case, the following features were considered necessary:

- Contract Management
- Maintenance
- Stock Management
- Establishment of key performance indicator (KPI's) for Benchmarking

3.2. Data Gathering

At this stage, it was considered not only gathering the data related to the drawings of the Center, required to modeling, but also the necessary information to manage it. The building data is in digital format and represent the as-built.

3.3. Modeling of the School Center

The modeling of the Center was performed according to the existing drawings. However, due to some changes made after construction, about which there is no information, a verification on field of these changes was necessary in order to represent the current state of the building, as-managed.

When performing the modeling of the Center, the information gathered for the equipment was also inserted. As seen in the figure below, during the modeling, both geometric and non-geometric LOD requirements were fulfilled. Another matter that must be taken into account in concerns to the specifications required for integration with the BIM-FM solution. In the figure below, you can also see a zone model, one of the requirements of the modeling.

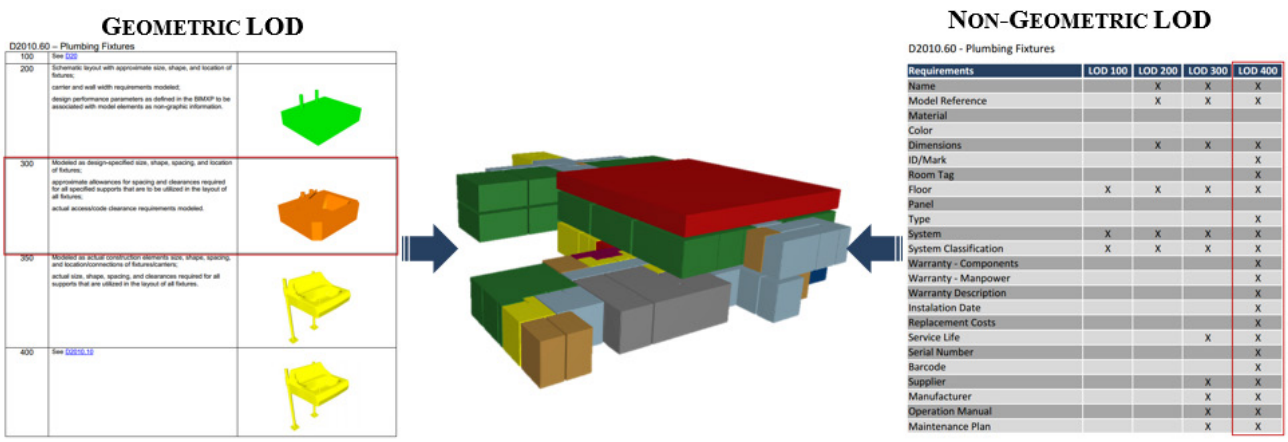

Figure 2 – Geometric and Non-Geometric data requirements

3.4. Integration with BIM-FM solution

One of the most important steps in BIM-FM implementation is the connection between the modeling software and the management solution. It is important to ensure that both solutions are mapping the same fields, in order to guarantee that all the data that is inserted in the model is synchronized with the management solution.

After modeling the building and the data insertion into the right components, this was synchronized with the Archifm.net.

From this point, the whole process of management is done in ArchiFM.net which is updated when necessary with the BIM model.

3.5. Development of FM Database

After its synchronization, is created the remaining necessary data. While most of the components data were automatically synced with the model, all the data related to organizations, employers, contracts, maintenance plans and others had to be inserted and created in the application. The insert of data was done mostly through Excel sheets, using predefined templates to ensure that all the parameters were correctly mapped and in a few cases it was manually inserted in the browser application.

Although the application has some formatted reports, it was also necessary to customize the reports to fulfill all the requirements regarding to KPI's.

4. CONCLUSIONS

The implementation of a BIM-FM solution has to be carefully planned, due to the amount of possibilities that have to be taken into account.

The utilization of this methodology also highlighted that the current association of the LOD with the building life phases does not match the real needs of the OM phase. Even though in the importance of 3D building model to FM, this does not mean that the model needs to have a high level of geometric detail. A new classification is suggested, where the LOD definition also shows its data requirements detached from the geometric information.

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Building energy analysis: Contribution of BIM methodology for sustainability in the energy optimization of buildings

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1. Introduction

This work results from research activities within the scope of the Master's Thesis in Sustainable Construction and Rehabilitation proceeding in the University of Minho, as well as the professional experience developed over the years as an architect.

Currently there is a growing awareness and concern about climate change resulting from increased CO2 emissions in recent decades, leading governmental institutions and the general public to demand buildings that are more sustainable and energy efficient. The demand for high levels of energy efficiency that enable a reduction of primary energy consumption and therefore lower CO2 emissions, imposed by European and national legislation, as well as the implementation of the new concept of NZEB to all buildings in Europe until 2020 [1], forces the need for AEC industry to adopt processes of interdisciplinary analysis that are more coordinated and integrated with each other, enabling shared and updated building information and knowledge through all stakeholders, from initial concept design to construction.

The implementation of BIM methodologies and tools in the AEC industry, therefore, reveals itself of great importance and promotes greater efficiency in the collaborative process between different actors.

According to Eastman [2], the definition of BIM consists of a modelling technology associated with processes in order to produce, communicate and analyse building models. The models are characterized by the inclusion of building components using parametric objects that contain the graphical representation and attributes that allow it to be handled intelligently, permitting several types of analysis procedures, including extraction of quantities, product specifications and energy analyses. The consistency and no data redundancy in case of modification of objects or model geometry, allows the production of coordinated, updated and reliable information on all views and reporting schedules.

The BIM applications allow the optimization of a more sustainable building, through an easy analysis of the constructive elements, energy efficiency, solar radiation absorption, sustainability, resulting in getting more accurate and efficient designs, as well as reducing losses of natural resources and less impact on the construction site [3].

The initial stages of building design are the most important for making decisions regarding implementing sustainable measures. The traditional method in CAD generally prevents the possibility of sustainability analysis in the early design stages, which are typically performed when the architectural projects are almost closed. This fact results in an inefficient process due to the lack of integration into the architectural design, leading to extensive modifications afterwards to meet performance criteria. This practice also leads to buildings that might be sustainable considering their energy consumption but not in their architectural aspects with economic and sustainability optimization consequences [4].

Recent studies indicate that initial investment of building increased by 2% more on systems that support sustainable design, which result in an average savings of 20% during the life cycle of the building, proving that sustainable buildings are also economically viable [5].

For the simulations to be effected at the initial project phases it is necessary for the model to contain information data relating to the shape and location of the building, material, openings with shading devices and MEP systems specifications. This opens an opportunity for the implementation of BIM, which can incorporate sustainability measures from the early stages of design, since the virtual model is a repository of all the information inherent in the building [5].

With the introduction of BIM methodology in workflows analysis for optimizing energy efficiency, energy simulations become part of an integrated process, enabling fast analysis of multiple solutions to provide accurate and reliable quantifiable results [6].

In this sense, the use of BIM tools and methodologies will contribute to sustainability through forecasting energy consumption and their respective usage costs with credibility, reliability and consistency of results, and may also benefit from accurate and complete estimates in the initial design, allowing early decision-making. It also improves analysis of the life cycle cost of a building and enable the measurement and verification of results during the occupation of the buildings, while providing the opportunity to learn processes and implemented solutions that are true validated.

With this work, one expects to comprehend the benefits and barriers to the introduction of BIM methodologies and tools in process simulation and energy analysis of buildings, as well as the analysis of the interoperability problems between BIM tools and specialized software for detailed energy analysis. In the same way, it is intended to analyse workflows that provide good efficiency, which will boost its correct implementation and adoption in the AEC industry.

2. METHOD

The main objective of this study is to test, improve and develop, with the use of BIM technologies, appropriated methodologies and workflows in building energy analysis through all project phases, making it become part of an integrated design building process and, therefore, an indispensable tool in the AEC industry, in order to achieve high levels of energy efficiency and sustainability.

To accomplish this it will be simulated the process of all the project phases of a building, from concept design to the construction drawings, like it would happen in a real life office. The purpose is to be as accurate as possible and extend the work beyond the scientific view and into the professional environment in which it will be implemented.

The building to be modelled is a small single-family residential building of the author's authorship, which will allow a focus on the processes of energy analysis, thus not consuming too much time to model itself. This way, it can also be tested more solutions that will enable a better energy optimization of the building. It will be developed initially in LOD 100, corresponding to the concept design phase, with the use of masses. Location with climate data, solar orientation, shape, openings location and dimensions, as well as dimensions and type of shading devices will be defined. Through this phase, several initial energy analysis with the purpose of choosing the best solution for building design optimization will be performed. After this phase, the model will evolve to LOD 300, in which the characteristics and properties of all building elements as well as the necessary HVAC equipment will be defined to achieve a more complete and final energy simulation before exporting to specialized software for detailed energy analysis. Similar to the previous phase, several energy simulations with the purpose of choosing the most efficient building elements to be implemented in the final design will be performed. The final design should integrate the most efficient solutions tested along the process, towards the optimization of energy efficiency, thermal comfort and daylight efficiency. As the last and final stage, the interoperability of BIM software and specialized software for detailed energy analysis will be tested, regarding the possible problems that could exist by exporting from one to another. For modelling and initial energy analysis, it was chosen Autodesk Vasari, Autodesk Revit and Autodesk Green Building Studio, from which the model will be exported for specialized software for detailed energy analysis, such as IES, Design Builder and Energy Plus.

3. PRELIMINARY RESULTS AND DISCUSSION

Concerning first results obtained through initial research and modelling in LOD 100, it is noticeable the ease and efficiency introduced in the process of initial energy analysis with the use of BIM technologies. Unlike the traditional method in CAD, where all the information was manually entered in a parallel process, making it a time consuming process with duplication of proceedings and prone to misinterpretation of design specialties from specialized engineers, the BIM methodology joins all the processes in one model and allows the project designer to intervene in the process of energy building optimization right from the start. There is a significant reduction of work and time required to model the building due to the introduction of BIM technologies and its LOD system workflow, as well as a release of accurate and reliable graphical and data information to analyse, allowing a more holistic and integrated view of all the work. It is also possible, and it will be studied further ahead, to analyse all building elements efficiency individually and forecast energy consumption with its respective usage costs with credibility, reliability and consistency of results.

4. CONCLUSIONS

At first conclusions, it may be highlighted that the adaption of BIM technologies is positive and the first results obtained are encouraging. It is possible to identify the ease and efficiency introduced in the process of initial energy analysis and that there is a greater understanding and self-awareness of the concept design solution impact in energy efficiency and, therefore, of the level of sustainability of buildings.

As an outcome to be achieved, it will be expected that the building energy analysis will be an increasingly fast, intuitive, efficient and reliable process which will be interoperable with specialized software for detailed energy analysis, due to the large existing BIM technologies and processes.

5. ACKNOWLEDGMENTS

Special thanks to my dissertation supervisor, Prof. Doutor João Pedro Couto for his full support and friendship.

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Using BIM for Energy Performance Simulation: Are We There Yet?

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1. Introduction

The advance of Building Information Modelling (BIM) in recent years expedited its use in a growing number of practical tasks. However, the continuously rising interest in BIM-based working and the related interoperability needs of more and more specialised AEC tools in various construction subdomains showed also that a global model for all data in a construction project is not a realistic target, and that BIM data typically have to be combined with other kinds of construction related data to be efficiently applied in practice [1]. Thus, while the current standard BIM specification IFC (ISO 16739) has been successfully extended to support various domain processes, the problem how non-BIM data or BIM-related non-AEC data from external resources can be best integrated with BIM is still relevant for many practical situations. Further¬more, the quality of the actual BIM data and the prerequisites a model should fulfil to efficiently support information interoperability in a specific domain are issues that should not be underestimated as potential sources of error or considerable time loss. This paper examines the possible use of IFC as information basis for energy performance simulation in building design. It discusses the challenges to data modelling in the domain, an approach to meet these challenges developed in the frames of the EU projects HESMOS (www.hesmos.eu) and ISES (ises.eu-project.info), as well as gathered experiences and encountered problems from preformed real practice studies.

2. MODELLING CHALLENGES

In the energy domain, numerous advanced applications exist, but they mostly use legacy type data schemas with order and layout-specific markups to represent the analysis models [2]. Thus, while it is widely acknowledged that the BIM/IFC standard is capable of providing a lifecycle project information repository that can potentially serve all construction subdomains to ensure integrated and coordinated project delivery, there are various other challenges that have to be met to support efficiently actual design work and tool interoperability. Such challenges include:

- Semantic level representation. Energy analysis and simulation models require explicit definition of spaces and their use, clear specification of exterior walls, proper differentiation and naming of openings etc. In an IFC model this must be represented not only on visual but also on semantic level.
- Appropriate geometry specification. Various energy analysis/simulation tasks demand that spaces are completely enclosed by elements with known thermal properties, taking into account all adjacent spaces to each element. This requires explicit specification of second level space boundaries in the model, wall and slab breakdown into appropriate segments, no gaps left in space enclosures and no element overlaps.
- Proper integration of external data. Various data from external non-BIM sources, such as meteorological climate/weather data, occupancy schedules etc. have to be correctly associated to BIM/IFC objects.
- Construction product specifications. In early design and in some retrofitting tasks the detailed construction of composite walls and slabs is not known but it is required by analysis/simulation tools along with all respective mate-rial properties of the separate layers, needed to determine properly overall element weight, U-values, Rw-values etc.
- Topology information specification. This kind of information is supported in the IFC schema but it is not mandatory and CAD tools used to create the actual BIM data typically do not provide it. However, energy analysis/simulation tools require such information. Thus, it needs to be re-created from the building geometry or defined from scratch.

3. NEED FOR A MULTI-MODEL FRAMEWORK

The integration of external data is an especially demanding issue in energy-aware building design because of the numerous external data that must be taken into account. Specifically, for energy performance analyses and simulations the following non-BIM data has to be considered: (1) Climate and weather data, (2) Extended material data providing the material properties needed for sophisticated energy analyses, (3) Construction templates providing ready-made configurations for early design decisions and/or substituting pre-fabricated building components, and (4) Occupancy / schedule templates. Each of these types of data requires a specific binding to the BIM data. Hence, extension of the IFC model to an energy-enhanced modelling framework (eeBIM) is necessary. Such a framework can be efficiently realized by the multi-model approach developed in the HESMOS project, coupled with the generalised definition of templates as ready-to-use design building blocks that was developed in the ISES project [3, 4]. The essence of the approach is in capturing the relationships of BIM data to external information sources within a separate Link Model, and resolving these relationships by means of model management tools at run-time. This does not require changes in the BIM schema and the external models used and it warrants maintenance of each model in its own domain (e.g. climate data main¬tained by meteorologists). However, it requires also the use of supporting BIM management services for: (1) Filtering of the BIM data to a model subset needed for the domain, (2) Creating and resolving the links in the Link Model used for the integration of non-BIM data, and (3) Mapping the eeBIM data to/from the computational models of the targeted energy analysis/simulation tools. Table 1 below shows the main model links supported by the developed eeBIM framework.

Table 1 – Principal multi-model links for the integration of non-BIM data for energy analyses and simulations

Multi-model issue	Related BIM concepts	Link type	Template use	Multiplicity
Climate data	Building; Facade	Explicit; Algorithmic	No	1:1; 1:N
Element constructions	Building elements (& subclasses)	Explicit (grouping; nested assoc.)	Optional	1:1; 1:N; M:1
Prefabricated elements	Building/distribution elements	Explicit (grouping)	Yes	1:1; 1:N
Occupancy / Schedules	Zone; Space	Explicit (grouping)	Yes	1:1 to M:N

4. PRACTICAL PROBLEMS

Experience from two performed pilot studies on real construction projects and several other test cases showed that the outlined BIM-based approach can successfully cover most pracitical project tasks [5]. However, there are also some issues requiring specific attention when choosing the appropriate tools and creating the actual building model data to be used in subceding energy computations. If caution with regard to such issues is not exercised the model may fail to provide correct input or worse, the simulation results may be wrong or misleading. This includes:

- Properly defined space use and space boundaries. These issues are often neglected when modelling the building with a BIM/CAD system. However, if space use is not correctly specified and space boundaries are not defined or incomplete the model will either be not computable or wrong occupancy schedules and set points will be used.
- Empty spaces with some technological meaning but no energy-related function. Such spaces should be excluded from the analyses and should not have designated use types, set points etc. to avoid misleading simulation results and excessive computations due to the increased number of zones to be taken into account. Many such spaces typically exist in a building, such as installation chambers or twin walls.
- Differing quality of neighboring wall or slab elements from energy point of view. Such elements are often modelled as one whole by architects but have to be considered separately by the respective

analysis/simulation tools. Resol¬ving the issue requires: (a) a service which converts first to second level space boundaries, and (b) automated use of construction templates to enable assigning of different thermal properties to the generated separate wall segments.

- Suspended ceilings. This commonly occurring issue presents an especially difficult case with regard to energy modelling. Suspended ceilings may be correctly modelled as hollow spaces in architectural CAD but depending on the actual height it may be more appropriate to treat them together with the floor slabs as composite elements from thermal point of view. This requires substantial geometric and structural changes in the model. Even if treated as hollow spaces on 1:1 basis, the "empty space" problem outlined above has still to be tackled.

5. CONCLUSIONS

Based on the gained experience from the performed industry studies it can be concluded that:

- The current IFC model specification is good enough as lifecycle repository and initial data source both for inter-disciplinary coordination and for the energy domain. There is no need to extend the model schema further because all missing external data can be successfully integrated via the Link Model approach demonstrated by HESMOS.
- Using dedicated model management services is necessary but this is not a specific IFC issue. It is inevitable when a general-purpose model has to be mapped to specific application needs. In this regard there is no big difference between the use of IFC and the use of the currently popular gbXML specification supported e.g. by Revit.
- There is a strong need for reusable IFC-related software solutions for repeatedly occurring project tasks such as the transition from an architectural model to an energy-specific model view, the derivation of space/element adjacency information from the available geometric and semantic data, or the automated detection and grouping of various meaningful subsystems that are not defined in advance, e.g. façade, roof, glazing etc.

Overall, despite the need for further work, the performed studies already showed quantifiable benefits both with regard to process and to building optimization. Work savings of 22 to 30% could be recorded and examined design alternatives brought improvement of 5 to 15% in performance [5]. Thus, using IFC for energy-aware building design can be seen as a valuable asset to be further developed and expanded. It requires new and more intelligent services and tools but also end user expertise in creating reliable models with regard to the new BIM-based method of working.

6. ACKNOWLEDGMENTS

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Exploring Advantages and Challenges of Adaptation and Implementation of BIM in Project Life Cycle

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1. Introduction

The paper was inspired by the current level of uncertainty that to what extent BIM affects the project life cycle. Indeed BIM is being rapidly embraced by the construction industry to reduce cost, time and enhance quality because owners are now realising benefits that BIM can offer them [1]. However, there are challenges that make the adoption of BIM much slower than anticipated [2]. A prominent challenge is the construction industry's reluctance towards new innovations due to the lack of knowledge of how to use BIM and understand what benefits can be attained [3] [4]. Therefore, it is essential that all project participants expand their knowledge and awareness to ensure they can fully obtain potential benefits of BIM and cope with challenges. This study did a literature review and its major focus was to identify the advantages, challenges and usability of BIM during the project life cycle.

2. BIM ADAPTATION AND IMPLEMENTATION BENEFITS

IBIM technology in general provides opportunities for project members to control important variables such as cost, time and quality in a more efficient and timely manner from early stages that leads to make more value creating decisions [2] [5]. The following are detailed BIM advantages in project life cycle, which in this paper is divided into 3 main stages: pre-construction, construction and post construction.

2.1 Pre-construction Stage

Early involvement of project stakeholders is required in BIM implementation. Although this increases upfront costs, the overall costs of the construction phase will decrease due to the savings gained by avoidance of delays, change orders, claims and requests for information [8]. The design decisions that are made in early stages will be more cost effective as in this stage the opportunity to influence positive outcomes is highest and the cost of changes is minimal [9]. Moreover, digital representation of the physical building enables the design team and project administrators to evaluate the design performance and to detect errors prior to production phase. This refers to performing quality control and ensuring constructability by detection, check and modification of geometrical design inconsistencies between different building components and installation systems [2] [5] [7] [10].

BIM tools increase the accuracy of the cost estimation process by improving information availability whereas traditional approaches often were insufficient [11]. The cost estimation (5D) can be as a foundation to control costs since it makes all involved parties aware of the costs associated with the design before it progresses to a more detailed level. As a result, design can be optimised to honour the client's budget [10].

2.2 Construction Stage

One of the major benefits of BIM during construction is a great reduction of rework by 40 to 90 per cent [2]. It is extremely attractive for large corporations due to the cost savings [12]. Furthermore, the visual nature of BIM contributes to planning and control the construction processes in advance which leads to better collaboration, reduced need for on-site inventories and minimised costs [10].

2.3 Post-construction Stage

The problem of acquiring accurate as-built information from the construction process has existed in the industry for a long period. BIM model, in theory, can substantially improve the facilities management since it contains important information in terms of manufacturer specifications and maintenance instructions linked to building components in order to provide an accurate database for client and operators [11].

3 BIM ADAPTATION AND IMPLEMENTATION CHALLENGES

Advantageous outcome of BIM can be obtained only if possible pitfalls in both organisation and project level comprehensively are taken into account [13]. The paper suggests that challenges triggered by BIM adaptation should be considered from four perspectives, namely (1) process related obstacles, (2) social context obstacles, (3) technical obstacles, and (4) associated costs.

3.1 Process Related Obstacles

Process related challenges have three aspects:

New business processes. BIM changes the traditional processes in building projects and accordingly construction organisations should adapt themselves to new business processes [6] [10] [13]. Nevertheless, due to immaturity of users and absence of any clear guideline, it is difficult to foresee the consequences [13].

New roles and responsibilities. Traditional interpersonal roles and relationships within the permanent and temporary organisations in an enhanced environment should change and the new roles in different processes have to be added [14] [15]. It is however ambiguous how they should be integrated into current processes.

Contractual changes – economic incentives and ownership of information. Development of new contractual agreements is necessary for BIM based projects to be able to deal with division of economic incentives and ownership of information. Specifically, it must be determined how economic benefits gained by BIM implementation should be divided between project participants and who has the right to access the information in the model [5]. There is another significant challenge that project team members are reluctant to take responsibility for the accuracy of information [16]. Hence, division of responsibility for maintaining and updating the information also needs to be addressed.

3.2 Social Context Obstacles

Social context obstacles are more about socio-technical gap. Alignment of the social nature of construction projects with the functionality of technology can be obtained only by training employees for new roles and enhancing the awareness of possible benefits [3].

3.3 Technical Obstacles

This challenge is investigated from two perspectives:

Problems of interoperability. Various organisations are involved in construction projects and they often use different types of software. Interoperability between all software is not guaranteed as many BIM vendors address interoperability only among their own products [17]. This makes the sharing of information and the communication between participants ineffective [7].

Lack of integration between the project phases due to absence of BIM software. Most of BIM software tools are not applicable to fit the both production and FM processes [3] [13]. This issue causes ineffective administrative work routines and gives restricted support to the crew on-site and facility managers [3]. Lack of technology alignment also leads to a digital divide between the design and other stages [6].

3.4 Associated Costs with Use of BIM

The costs associated with acquisition of BIM software and hardware, training the staff to operate them and developing the building information model makes the industry reluctant to employ the BIM.

4. CONCLUSION

This research provided substantial evidence on the current understanding and perception of BIM benefits and challenges during project life cycle. The findings show there is an insufficient knowledge to develop a clear guideline and to quantify the advantages gained by BIM. As a result, owners still have a dilemma of making decision that whether they should utilise BIM based on perceived benefits from theory. It was also noticed much of the existing research material have focused on technical barriers whilst associated barriers with people, management and costs were neglected. It is suggested to develop consistent and adaptable guidelines for all sectors in the industry and organisations with different sizes. These guidelines should be able to quantify benefits and consider both monetary and managerial outcome.

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Information Handover Using BIM to Support Safe Facility Management Processes: Current Challenges

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1. Introduction

According to the United States Bureau of Labor Statistics, 290 people lost their life from 2008-2012 in the field of General Maintenance and Repair, also known as Facility Management (FM) (Bureau of Labor Statistics 2009a - 2013a). In that same timeframe, employers recorded 98,280 cases of occupational injuries and illness, with 25,890 cases requiring a minimum of 31 days away from work (Bureau of Labor Statistics 2009b - 2013b). Workers carrying maintenance tasks are at constant risk of electrical shock, falls, cuts, and bruises and as a result, have a much higher rate of injury and illness than the national average (Bureau of Labor Statistics 2014a).

Case study analysis confirms that many of the recorded accidents could have been avoided had the victim followed appropriate hazard mitigation steps to safely execute a facility management tasks, defined here as safety protocol. Currently, safety information is conveyed to FM staff through training seminars, O&M manuals, plans & specifications, safety meetings, and safety literature. This information, although comprehensive, is often fragmented among multiple resources as shown in Figure 1 (Goedert and Meadati 2008; Lucas 2012). Research has shown that the more time and effort an individual must spend obtaining information, known as inconvenience, the less likely they are to retrieve the information and follow the stated warnings (Godfrey et al. 1985; Wogalter et al. 1989; Zeitlin 1994). Conversely, minimizing the amount of time and effort to the lowest possible level of information retrieval, has shown a much stronger likelihood of safety protocol implementation (Zeitlin 1994).

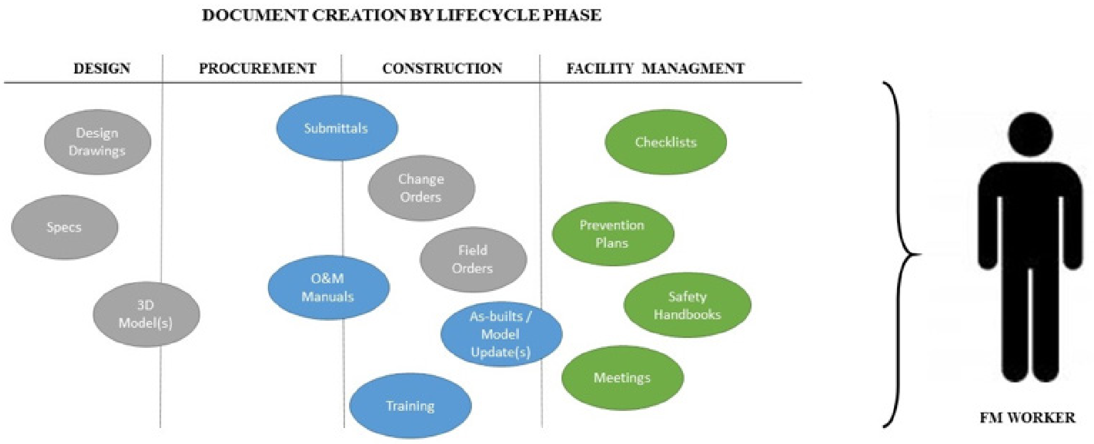

Figure 1: Fragmented Safety Information

2. MATERIALS AND METHOD

This research work focuses on the consolidation of safety information through the use of a BIM-based product model and ontology within a graphical user interface (GUI). By combining the product model and ontology with a GUI, an FM worker can interact with a singular repository for safety information, eliminating the need to reference multiple resources in order to obtain comprehensive safety information. This study identifies safety protocol often encountered by FM staff during the repair and maintenance of a facility.

A business process model of data inputs to guide the information exchange and management of data within the product model are developed for the storing of safety protocol through the buildings lifecycle, as well as the framework for the outputs of these data for user interface. Lastly, a conceptual model is developed to demonstrate functionality of the graphical user interface. The goal of this research is to provide a product model and ontology that when combined with a GUI, can be enacted by FM staff to obtain job specific safety information prior to the start of a work activity. Accessing safety protocol information within the GUI will aid in the mitigation of risk associated with FM tasks by requiring the FM worker to answer questions regarding the upcoming work activity. This urges the worker to proactively consider the safety plan. Upon completion, the GUI provides an output of safety protocol based on the responses of the FM worker, thus eliminating the requirement to reference multiple resources. Figure 2 illustrates the basic components of the proposed framework.

3. RESULTS AND DISCUSSION

Extraction of safety information across facility life cycle to support the proposed framework has various challenges. Safety information is fragmented and will often come from a number of sources (i.e. project players) during the

lifecycle of a project. Because of the number of sources supplying safety information, extraction of such data faces various barriers or "Handover Issues" (Cleveland-2014). These include specialized/varying software, naming conventions, error prone, formatting and data structure, lack of expertise, and data size. Without mitigation, the barriers described as "Handover Issues," will complicate or hinder the retrieval of the needed information. Fragmentation of applicable safety information within multiple project documents creates inconvenience in obtaining comprehensive information, reducing the likelihood of reference by FM staff. This has been shown to have a direct correlation to work related fatalities, injuries, and illnesses.

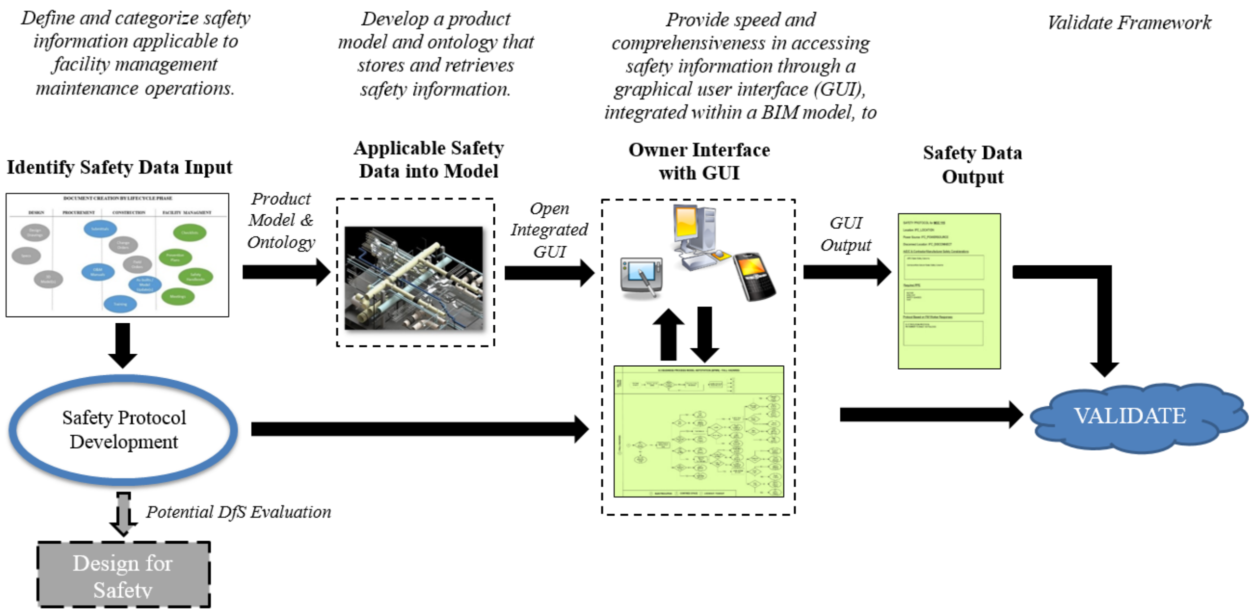

Figure 2: Proposed Framework

4. CONCLUSIONS

This research will discuss the current need for facilitating necessary information to perform facility management operations in a safer environment. A proposed BIM framework using a product model and ontology within a graphical user interface (GUI) will be discussed. To achieve the proposed framework, challenges and barriers associated with extracting safety information from various sources across facility life cycle need to be resolved.

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Building product manufacturers integration in the BIM process

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1. Introduction

One of the most usual statements in the BIM process is that the main thing is the Information. But when we hear that, we should also ask what information? Where does it come from? How accurate is it? Is it updated?

A great deal of information on a BIM model regards manufactured building products whose information comes from product catalogs delivered by different brands. But it is still quite common that BIM model development gets developed based on static and generic geometry representations of products (CAD based geometry) with manual insertion of information extracted from manufacturer's catalogs.

BIM managers and BIM users all over are still creating their own versions of manufactured products geometries and information, either using CAD blocks, modeled from manufacturer's catalogs or using lookalike representation taken from someplace in the internet. Many will claim geometry is not that important, "the main thing is the attached information". But even then, this method for information placement is static, time consuming and very prone to error. It also places building products manufacturers out of the BIM process and raising different liability problems.

As far as manufactured products placement in BIM models, we believe the information should only come from manufacturers in the form of BIM product library parts, placed by the designers or the manufacturer's themselves as project stakeholders. Us at concepsysBIM, we have worked closely with manufacturers inside and outside Portugal for the last three years now and as we see it, although every manufacturer goes to a great deal of effort, time and money to make their product information available or to be placed in construction, they still are not investing in developing their product as BIM representations. The main obstacle to this action that we come across is the absence of demand. "No one asks us to deliver such files" they say. So we have manufacturer that even today are spending money developing 3D CAD library parts, and have never heard about BIM.

We believe BIM users keep just using generic library parts that come with every BIM software or modeling and inserting information themselves instead of asking manufacturers for their own enriched information, smart library parts. We can say that today most building product manufacturers are somewhat distant of the BIM process. They aren't invited to participate, they aren't asked for their BIM library parts, yet the web is filled with free CAD unofficial representations of their products, (sometimes very inaccurate representations even), without any information of branding, that poorly represents the product. This poses a product control product to the manufacturers that in most cases would be more than happy to freely develop, distribute and manage content in BIM formats regarding their products. But most of the time they are not asked for that.

Library parts are one of the most productive ways to place information inside a BIM model. So every manufacturer has to start making their products available under the form of library parts, seen as bit of geometry and information.

But library parts must follow BIM rules itself, concerning level of detail, level of development, information format and standards, etc.

In the other hand one single product might present different catalog characteristics such as color, dimensions, material, physical properties, which combined may generate hundreds of catalog references. Library part management poses a real change both for manufacturers as well as for BIM managers.

The solution we point out is programed parametric BIM library part development.

2. MATERIALS

2.1. Introduction

First part will materials will illustrate the need for building product manufacturers to be called to participate in the BIM process.

2.2. Parametric smart bim object library part development – Case study – telhas COBERT

Based on one manufacturer product we will quickly go through the main steps of smart library part development, from product laser scanning to interactive catalog development.

We will show how product information can be created through the use of smart BIM object library parts.

We will show how parametric information will supply smart and updated information inside a BIM model.

Figure 1 – telhas COBERT smart BIM library parts.

3. RESULTS AND DISCUSSION

Direct BIM user demand for BIM product representations (library parts) to building product manufacturers is mandatory to make product brands start developing and making their products available as BIM information. In time, and looking at the increasing responsibilities involving all stages of the BIM process, placing manufacturer certified BIM information will be the only acceptable way to insert BIM product information in BIM models. Building product manufacturers must be summoned to the BIM process. No one can understand better building conditions, limitations, product availability, product application, product information management, of building products then the manufacturers.

But not every BIM "content" will do. Most content is still made in a CAD style fashion. Good BIM content must consider LOD, product characteristics, and even become productivity tools to whoever gets to place or use the product inside the BIM model. Having the best smart BIM library parts developed by the product manufacturers is important for the overall BIM implementation process, and right now BIM users play a very important role educating manufacturers, that usually respond very directly to effective demand.

4. CONCLUSIONS

It is very important that BIM users ask building products manufacturers to come forward and make their products available to the BIM process. Their presence will assure the BIM process will become:

Less time consuming;
More accurate;
Have less liability problems;

The sooner this happens, the better.

Development of mobile BIM applications for building inspection

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Mobile devices are increasingly seen as important components in the adoption of BIM throughout the construction lifecycle. They play an especially relevant role beyond the design stage. Current mobile hardware supports 3D graphics and allows different forms of user interaction and connectivity, along with the obvious advantage of portability. Major BIM software developers have recognized the potential of mobile technology and currently provide a variety of applications that allow users to access a subset of the information that composes the original BIM model. This article presents a mobile BIM application that has been developed to support building inspection tasks. A compatible web-based reporting application and an add-in that allows the information that is gathered on-site to be accessed and edited from Autodesk Revit are also presented.

Current BIM tools allow information to be exchanged using a variety of alternative data formats. Amongst these are 3D file formats such as FBX or OBJ, besides IFC files or ODBC. These alternatives can be included in a broad framework that allows bidirectional information exchange between commercial BIM software and custom-built BIM applications (including mobile and web-based solutions).

Since several different data formats are to be used simultaneously, it is crucial that each individual BIM object is identified consistently throughout the framework. This requires an empirical assessment of all the software tools that will be used to ensure that all GUIDs are preserved throughout the process.

A growing variety of 3D engines, including open-source alternatives, can be used to merge these different sources of information, to develop immersive 3D interfaces for BIM applications and to deploy them on different hardware platforms.

A mobile application with a 3D interface (Figure 1) has been commissioned by a large Brazilian construction company and has been developed to support building inspection tasks.

Although the company currently uses BIM tools to develop models during the design and the construction stages, it uses a paper-based approach to perform construction quality assessment tasks, both on-site and in the factory for its prefabricated structural elements. Each individual element is inspected at least three times, at different stages, and a standard report is issued after each inspection. This requires quality supervisors to carry the inspection forms and fill them in on-site and to insert the results into the company's information system for further processing upon their return to the office. This approach fragments the information flow and separates an essentially BIM-based process that occurs in the office and a formal quality assessment process that does not rely on BIM, neither during the on-site inspection tasks, nor for processing and reporting results later on.

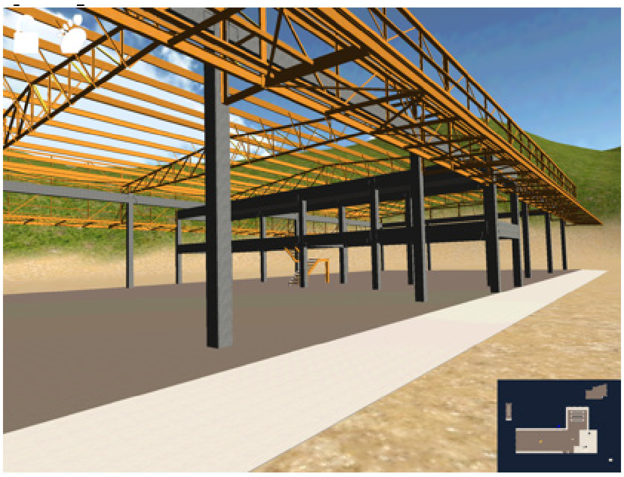

Figure 1 – Mobile 3D interface

The mobile application should have a simple interface for on-site use and should be able to export results in standard formats for further processing and for reporting. Since permanent Internet connectivity cannot be guaranteed on-site, results should be stored locally using an embedded database system, and synchronized with a remote database upon request.

This data synchronization procedure allows multiple users to work collaboratively on building inspection tasks and provides real time data access for reporting purposes.

A common software component [1] is used to provide a BIM-based 3D interface. Another software component has been developed to generate the data-entry forms on the fly (Figure 2) with no further programming required. This was a requirement in order to allow new data forms to be developed and existing ones to be edited quickly by AEC professionals without having to access the code.

An effort was made to emulate the paper-based approach as much as possible, in order to ease the transition to the new, integrated process. Although data-entry forms were designed to resemble paper forms, they were simplified. On one hand, all of the paper-based footnotes that contained simple descriptions for the inspection procedures were made available in full detail elsewhere inside the application interface. On the other hand, since all the inspection history for a given element is registered in the database and can be accessed through reporting tools, it does not need to be a part of the data-entry interface. The data-entry system is context sensitive, which allows different forms to be generated, depending on the type of object that is selected by the user in the 3D interface.

Since the company uses BIM for other tasks besides building inspection, an add-in for Revit has been developed to allow information gathered onsite using the mobile devices to be merged into existing models and accessed in the office (Figure 3).

Figure 2 – Data-entry form.

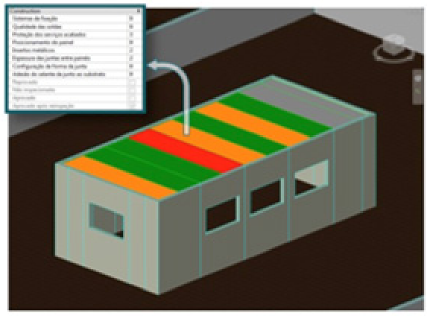

Figure 3 – Interaction with Revit model

A simple web-based application has been developed to make all inspection data stored in the central database available from the Internet. The web interface was also designed to emulate existing paper-based forms (Figure 4).

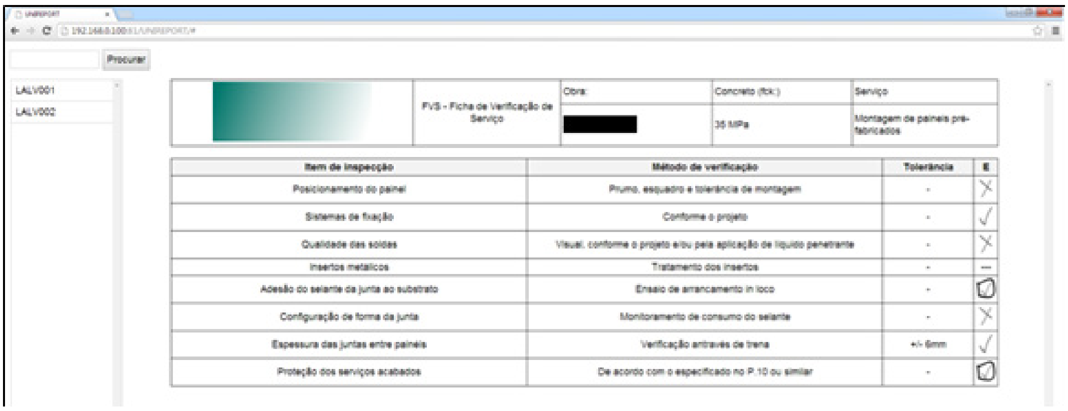

Figure 4 – Companion web based application emulates existing paper-based forms

The software tools described in this article were developed to suit the specific requirements of the construction company that commissioned them. They provide a 3D interface, built from existing BIM models, to access individual construction elements. Information inserted by the user about these elements is stored and shared using standard database solutions. This information can also be accessed through a web application or commercial BIM tools. On-site testing is expected to begin in the following months.

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Bridging the Gap – Executive Training Methods

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1. Introdução

According to the latest statistical findings [1] (p.12)*, the speed and level of BIM implementation in the UK is gaining momentum. But how does it look from behind the scenes – and where lay the uncharted challenges? As a network of BIM proficient professionals we witness repeated models of self-defeating behaviour among the companies. We could sum up the issues within the following broad categories:

1.1. Areas for improvement:

Internal communication; hierarchy; decision-making processes; interdisciplinary exchange; timing

1.2. Tendencies to counter:

Client driven change (vs. management led benefit strategy); psychology of resistance in the larger team (vs. trust in the knowledgeable approach of the leaders)

A well-functioning internal system in a company means quicker adoption and higher immediate profits. Hence restructuring the roles and communication network are the fundamental steps to begin with, much more important than the software purchase or the number of seats.

By and large the managers are still inclined to think of 'the BIM adoption' as a necessary evil, which could be sourced from outside the company by hiring experts, rather than understand it as an internal process, requiring their total involvement.

Of course some of the challenges we encounter are specific to the particular market – in the UK historically there is a split of expertise – the decision makers have long left the production hall, the designers are not involved with detailing and the technically apt get stuck into the nuts and bolts of it, while the 'bigger picture' of the programme, cost and deliverables remains exclusively reserved for the project managers. The latter are constantly busy and not very keen on relearning their trade. In general they are the best candidates for the role of the BIM strategy leaders in an office, but they seem to shy away, already carrying large amounts of coordination responsibilities.

As the following graph demonstrates (Fig. 1) – once a functioning BIM system is in place, the work-hours balance on a project changes substantially:

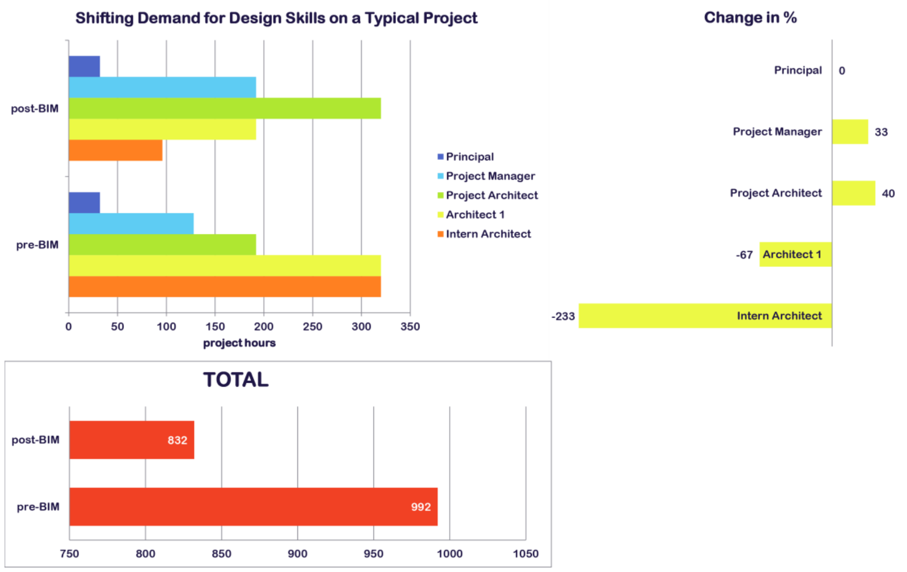

Figure 1 – Shifting demand for Design Skills on a Typical Project [2](p.259, table 5-5).

The biggest workload then falls upon the Project Architect and Project Manager respectively – meaning that these two should be the first to learn how to play the new instruments to continue the music.

The graph also explains why we get so little attention from the Principals / Directors – their involvement hardly changes – perhaps they assume it is the case for everyone. The essence is that the new strategy will require already experienced people, with upgraded set of tools, rather than juniors and trainees, despite their mastery of software [3] (p.130&218).

People in the highest positions should be fully aware of the connotations.

2. Materials and Methods:

Having identified the problem and the target group we had to think how to bridge the education gap. The solution we came up with is the in-house 'Executive training', aiming to give the managers a basic set of skills to go about the model and extract/ check information live. All orchestra conductors play at least one instrument well.

2.1. The training plan:

From experience we selected the following skills as the most urgent to adopt:

1. Understand the 'live broadcast' nature of the model and the necessary organization, accuracy and discipline of the work process to achieve the desired graphical outputs. Learn to observe, check and explore the 3D model in real time and not only its 2D projections. Way finding – where to look for what. Perform essential 'clash crosscheck'.

Anecdotal evidence – a whole model drawn as graphical representations in each and every 2D view without any real 'model elements'; lift shafts used as risers by the consultant; columns in the middle of the windows;

2. Learn to control the visibility of elements and all the various ways to hide/ show objects. Understand the levels of detail and the restrictions of the software to achieve the set of deliverables in the most fluent way.

Anecdotal evidence – 38 sections through the same spot (every time a new one); the mystery of the disappearing revision cloud (on a switched off revision set); modelling of the structural reinforcing by an architectural technician in the concept stage of a project;

3. Learn how to create, edit, sort and filter schedules/ data spreadsheets to monitor the actually present information in the model. Discriminate between the various annotative options – which preserve cross-referencing, and which not. Learn how to use the power of shared parameters to tag and schedule custom items.

Anecdotal evidence – trying to create a room schedule without creating first the rooms; drawing a coloured scheme plan with regions; placing 'flying' elements away from the model; 'tagging' doors with text and expecting it to update

Curriculums 1.+2.+3.+ research on historical performance of similar projects= (give) sufficient confidence to select that particular model structure, which best fits the mapped project route, and allows delivery at the required speed and consistency level – avoiding the foreseeable bottlenecks from the onset.

Anecdotal evidence – 8 linked models with sheets to publish in each of them and no view templates nor 'link by view' setup vs. 'documenting model' with over 700 sheets and 15 people working in it simultaneously before the deadline;

2.1. The outcomes:

When the leading designers in a company have learned how to use and manage the tools, they were able to achieve substantial modelling expertise within a relatively short period and could outperform any trainee or technician, using the model to develop the design on the spot – without the lengthy discussions and sifting of information through various levels of hierarchy, characteristic for the more traditional route. The speed and quality of vital project decisions rose substantially and the team efficiency improved by a third, as the 'head' knew where to lead them.

A trained Project Manager was able to deliver a package alongside his team, improving their speed by a good 10%.

3. CONCLUSION

To achieve sustainable system and consistent results we need the whole team on board with the leaders taking the first steps. They still have some psychological obstacles when it comes to new techniques or concepts, as their leadership seems questioned, but overcoming the traditional mind-set proves highly beneficial.

People are always more inclined to look for advice among their peers and colleagues [1](p.14) – hence the educative sessions should take place in-house, ideally in informal atmosphere. The training should provide essential skills and respond to project-particular issues. Those in charge should be able to take informed decisions and participate in the programme delivery in real terms throughout the process.

Keeping the system integrity in check, the team should actively search for improved methods to deliver [3](p.214).

A flattened team structure with regular round tables improves substantially the level of involvement and responsibility of the team members. Speaking the same language and sharing fairly the agenda of deliverables avoids the unnecessary operations and increases the mutual trust. Feeling a stronger link with the process, people are more inclined to give opinions, report a problem or suggest a solution, which greatly lightens the managers' task. Cooperation begins with willingness to work together and to the same end – enhanced efficiency can only help.

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Learning, teaching, researching and applying: a way into the theoretical and practical BIM framework

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1. Introdução

We started the basis of this work about five years ago, seeking to reduce the effects of information redundancy in computer models required for building environmental performance simulations: lighting; thermal; ventilation and acoustic. At the time, BIM potential could be inferred, and we set up more two themes to be investigated: Context and Collaborative Work. Context revealed two approaches that distinguish BIM and Parametric Design essences; and Collaborative Work involves IT and Construction Information Systems, necessary to handle planning, data organization and management requirements.

2. MATERIALS AND METHOD

Exploring BIM gradually has been recommended as a strategy to deal with the huge extension, complexity and potential involved in the BIM process [1, 2]. The research resources involve undergraduate students and their corresponding individual scientific initiation research projects. Each student focused on one theme consecutively, and all of them were integrated within a major research line "Digital Technology for Teaching and Production of Architecture, Urbanism and Design" under the author's coordination. To bring into line theory with practice, the method integrated didactical and academic extension activities. Academic extension projects and classroom workshops tested the procedures and gave the experimental results.

Three themes were settled and the research approach followed this sequence: (A) Performance Analysis; (B) Context; (C) Collaborative Work. These individual student research projects are briefly described below.

2.1 Computational Simulation Modelling and Information Redundancy. 2009 / 2010 (A)

Objective: to reduce the effects of information redundancy in models required for building environmental performance simulations. This research involved two disciplines: digital modelling and environmental comfort analysis. The student investigated mainstream building environmental performance analysis procedures. This usually involves the production of distinct virtual models for the same object, according to each analysis software requirements. Parametric modelling within the BIM process emerged as a possible way to provide a universal 3D model, and the research aimed to produce guidelines and procedures for model definition and compliance with individual analysis software packages.

2.2 Emerging Computational Tools with BIM Approach: Practice, Theory and Didactic. 2011 / 2012 (B)

Objective: to elaborate a model that explains and represents concepts within BIM and their inter-relations.

Digital design has several branches and is difficult to deal with, taking all possibilities of use into consideration. There seemed to be some misunderstanding of the concept of digital design and BIM, in Brazil. The research comprised a thorough revision of the literature, with special attention to two related branches: BIM and Parametric Design.

The proposed model adopted both and produced a guide schedule with parameters and criteria for analysis and classification of building projects. The guide schedule was tested and applied to ten examples in distinct periods and of differing nature, involving practice and didactic approaches.

2.3 BIM process collaborative work. 2013 / 2014 (C)

Objective: To identify available resources and design team interaction transformations arising from collaborative work within BIM. Until this research project, software resources for supporting collaborative work had not yet been assessed in our research. The student conducted a careful revision of the literature regarding collaborative work within BIM. The assessment tested intra-disciplinary and inter-disciplinary collaborative work procedures, respectively in LAN and WAN environments.

3. RESULTS AND DISCUSSION

To cope with the full BIM scope, we notice essential features within the Professional and Academic realms [3]. Whereas the former needs a strategy for quick response within a dynamic production environment, on the latter, the main resources are focused on the problem domain, dedicating more time to deepen analysis and theoretical thinking.

Research work (A) set the foundation stone for the assessment of BIM in teaching and practice, considering, not only design efficiency, but also building environmental performance. In real life, the building environmental performance analysis interaction is rather complicated; one analysis may be connected to different concurrent design activities, resulting in the analysis becoming part of the design process [4]. Each computational simulation requires its specific model, but after the analysis the original building model must be revised and the changes reworked in the other application specific models and so on. The model built using parametric modelling within the BIM process was exported in the formats gbXML and DXF, respectively required by the thermal and the lighting analysis software considered in the assessment. Data input and analysis were successful, though some compromising was necessary in the design for the models to work properly.

Research (B) devised a model for classification of BIM and Parametric Design approaches, separating detailed design and construction management from conceptual design. Differing natures yet with overlapping functions, this approach favoured analysis and classification, demystifying computational technology as the only possible transformation agent. In this sense, analysing retrospectively Utzon's documented design process for the Sydney Opera House, the architect's "systematic approach, his inspiration, design methodology and final design product appear to have much in common with the properties of parametric modelling" [5]. The cited authors aimed to conciliate the original analogue modelling, using ellipses and parabolas taken from a sphere, in an exercise that explored the potential for design refinement using CAAD. One can clearly identify the prevalence of Parametric Design in the Conceptual phase and the potential for BIM in the subsequent design refinement, construction and management phases, mainly as a support for the architect, who drives the entire process. The same can be said about Gaudi´s peculiar design process that applies mathematics and physics to derive form. In both cases, the results surpassed their historical moment and the technology available, advancing a procedure that would take place decades later, with the use of computational resources.

Collaborative work was deepened in research work (C), studying two scenarios: intra and inter-disciplinary file sharing organization. Intra-disciplinary simulated collaboration within the architecture team, and was tested in an undergraduate course selective discipline final class, enlarging students' comprehension about BIM potential and concepts. Inter-disciplinary framework was based on sharing of linked files [6] and coordination monitoring concepts [7]. Different complexity levels were identified concerning intra-disciplinary and inter-disciplinary collaborative work procedures, and future research themes were identified. Both were well succeeded within a LAN, yet presenting some problems and limitations when extended to a WAN.

4. FINAL REMARKS

Academics and practitioners play distinct roles concerning BIM. Hence, the understanding about resources and requirements in each sector reveals different strategies. This work embraces several issues, balancing both the human and the technical sides. Academic activities outcomes differ from the professional ones in time, focus, investments and responsibilities.

Academic environment allows more time for research and careful reflection, yet some areas like architecture and engineering should combine experimental and experiential learning [8]. "The challenges for the research community lie not only in addressing the technical solutions or addressing human centered issues but it is also in creating the enabling environment of a decision framework, which integrates both the technical and non-technical challenges" [9].

The individual research projects described are part of a major research line that connects and applies the findings in didactical and practical experiments. Classrooms workshops and academic extension activities – such as the design of an actual residence building under construction [10] – have been operating as laboratories for exploration and testing of concepts in search of the best practices regarding BIM.

5. ACKNOWLEDGEMENTS

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BIM RESEARCH IN THE LAST DECADE

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Academic interest in new methodologies, such as Building Information Modelling (BIM) has risen considerably in recent years. In this paper the definition of Building Information Modelling is described based on existing research and ten years of research on this subject is examined in detail. The research articles are classified according to relevant conceptual groups, which help to systematize the research conducted over the years. The findings evidence an increase in research regarding the practical uses for BIM over the years.

1. Introdução

At 1992, for the first time, "Building Information Modelling" (BIM) term appeared in a paper [1]. However, only after two decades this new methodology has been described by Eastman, in BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors, which was the first book to describe extensively all the major topics of BIM as technologies, standards, building design and construction [2].

BIM methodology has been developed in the last decade, with the advent of refined Computer Aided Design (CAD) systems, enrichment of 3D models of buildings and complementary data (as physical characteristics, unit cost, etc). According to Grilo et al. (2010) BIM is a process that promotes a more cooperative work between all specialties during the different stages of the construction project and also used during the life-cycle of the building [3]. BIM has also received special interest of specialists due to its application on energy simulation, being able to reduce cost and time required for geometry modelling [4].

2. RESEARCH METHODOLOGY

Research reviews enable researchers to have a wide view over the research conducted in a specific area and are an effective instrument to identify trends and patterns in the research literature. The longitudinal nature of the review enables to identify eventual gaps in the research and may allow identifying major research themes, which can have vary in importance over the years or depending on the industry in analysis.

The research approach considered in this case consists of a meta-analysis of the research literature; research articles for the period 2004-2013 are gathered from various scientific journals and analysed in a structured and systematic way. The time frame considered covers the last ten years, which cover the most relevant phases of the research, development and implementation of BIM.

The method adopted consists of three main steps: article selection, journal selection and final article selection. The journals considered for the study were selected based on their ranking within the discipline (http://admin-apps.webofknowledge.com) and their impact factors (it only has information until 2012). In order to guarantee the quality of the research a maximum number of journals have been considered, with an Impact Factor greater than 1. Among the list of journals identified, publications were searched using the following keywords: "BIM" and "Building Information Modelling".

The database used for this research was WebofScience (http://apps.webofknowledge.com). The preliminary list of articles obtained has been refined based on the available abstracts, which allowed generating a more concise list of articles, and based on journal's Impact Factor, which resulted on the final article selection. At the end of the selection process, 107 articles have been identified for deeper analysis.

The following table lists the 107 articles selected by year and respective journals.

JOURNALS	2006	2007	2008	2009	2010	2011	2012	2013	Total
ADVANCED ENGINEERING INFORMATICS	0	0	2	0	0	4	3	3	12
APPLIED ENERGY	0	0	0	0	0	0	0	1	1
AUTOMATION IN CONSTRUCTION	2	0	1	2	10	18	8	26	67
BUILDING AND ENVIRONMENT	0	0	0	0	1	0	1	1	3
COMPUTER-AIDED CIVIL AND INFRASTRUCTURE ENGINEERING	0	0	0	0	0	0	0	0	0
COMPUTER-AIDED DESIGN	0	0	0	0	0	0	1	1	2
COMPUTERS ENVIRONMENT AND URBAN SYSTEMS	0	0	0	0	0	0	0	1	1
COMPUTERS IN INDUSTRY	0	0	0	0	0	0	1	1	2
CONSTRUCTION AND BUILDING MATERIALS	0	0	0	0	0	0	0	0	0
ENERGY AND BUILDINGS	0	0	0	0	0	0	0	1	1
ISPRS JOURNAL OF PHOTOGRAMMETRY AND REMOTE SENSING	0	0	0	0	0	0	0	1	1
JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT	0	0	0	0	0	0	0	3	3
JOURNAL OF COMPUTING IN CIVIL ENGINEERING	0	0	0	1	1	1	1	7	11
RESEARCH IN ENGINEERING DESIGN	0	0	0	0	0	1	0	0	1
SOLAR ENERGY	0	0	0	0	0	0	0	1	1
WASTE MANAGEMENT	0	0	0	0	0	0	0	1	1
TOTAL	**2**	**0**	**3**	**3**	**12**	**24**	**15**	**48**	**107**

Table 1 - Reviewed journals and number of articles by year

The journal Automation in Construction has published the greatest number of papers on BIM, with a total of 67.

3. CLASSIFICATION OF LITERATURE

The classification of the reviewed literature can be derived deductively or inductively [5]. In the former case the structural dimensions and related analytic categories are selected before the analysis of the articles; in the second case, they are developed based on the content analysis made. In order to systematize the analyses of the articles, major conceptual categories have been defined, based on the most relevant subjects focused by the scientific articles analysed. In the next table it is shown the papers published each year and its distribution by the conceptual categories defined.

CATEGORY	2006	2007	2008	2009	2010	2011	2012	2013	Total
4D BIM AND SCHEDULE MANAGEMENT	0	0	0	0	0	3	1	4	8
BIM ADOPTION AND STANDARDISATION	0	0	1	1	3	5	1	6	17
BIM AND 3D LASER SCANNING	0	0	0	0	0	0	0	7	7
BIM AND AUGMENTED REALITY	0	0	0	0	0	2	0	4	6
BIM PROGRAMMING	1	0	0	1	1	3	2	5	13
BIM TRAINING AND EDUCATION	0	0	0	0	0	1	0	1	2
ENERGY PERFORMANCE AND LIFE CYCLE ASSESSMENT	0	0	0	0	0	2	3	6	11
FACILITIES MANAGEMENT	0	0	0	0	0	0	2	4	6
INFORMATION AND COMMUNICATION IN COLLABORATIVE ENVIRONMENTS	0	0	1	0	6	2	3	8	20
INTEROPERABILITY	1	0	1	1	2	5	2	1	13
QUANTITY TAKEOFF AND COST ESTIMATION	0	0	0	0	0	1	1	2	4
TOTAL	**2**	**0**	**3**	**3**	**12**	**24**	**15**	**48**	**107**

Table 2 - Categories by years

As shown in the Table 2, there were no published papers until 2006, but that scenery changed after 2010. Only in 2013 started to appear papers regarding BIM and 3D laser scanning, while there is a lack of research of BIM training and education, which might indicate that the universities are not keeping up with the new trends (although this study only takes into account papers published from journals with an Impact Factor greater than 1.0). Interoperability had its peak at 2011 and then decreased, while BIM Programming increased the amount of published papers. This may be related to some interoperability issues that were solved, supporting the development of BIM Programming. Energy performance and life cycle assessment and 4D BIM and schedule management also gained new awareness lately.

4. CONCLUSION

In the last decade, considerable research has been conducted, mainly in the last 4 years, focused on BIM and its uses. The present study evidenced the growing importance of this subject and permitted to identify major areas of research. Among them, some are especially important such as BIM adoption and standardization, Information and Communication in Collaborative Environments, BIM Programming and Energy performance and life cycle assessment. New trends were identified, as 3D laser scanning, as well as unexplored fields in BIM research, as in training and education.

5. References

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[4] Ahn, K.-U.; Kim, Y.-J.; Park, C.-S.; Kim, I.; Lee, K., BIM interface for full vs. semi-automated building energy simulation. Energy and Buildings, 68 (2014), pp. 671-678.

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Getting Started in BIM | The development of a concept design and cost plugin for architects, cost estimators & clients.

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1. Introdução

Unlike in the UK, in many countries in the EU (and beyond) BIM uptake has been relatively slow as clients and consultants fail to grasp the benefits of the process or think that BIM is too complex and expensive for them to adopt and deliver real improvements in their own working processes and deliverables.

Nothing could be further from the truth with readily available tools like Sketchup, bringing affordable BIM straight to architects using simple new workflows with software they already know how to use, and with it, the ability to collaborate with clients, cost estimators and other members of the design team right from the very start of a project.

In many countries the architect is also required to provide cost information as well as design information right from the inception of a project. New, simple BIM processes offer the opportunity to do this at greater accuracy, automatically and at significantly reduced timescales.

2. MATERIALS & METHODS

Analysis of existing software tools (mostly American) have indicated that there is a gap in the market for affordable, easy to use software tools that capture clients requirements digitally, automatically generate, and then allow the user to manipulate 3D spaces into a concept design and apply cost information to the developing design from first principals. In the current concept design workflow there is no digital process for interrogating cost directly within the modelling environment, leading to costly redesign when project budgets are exceeded.

Additionally, there is a disconnect between essential design workflows (thermal modelling for example) when these processes are undertaken too late in the design process which leads to significant amounts of redesign which is costly and time consuming.

The existing 'front end' tools we investigated had significant deficiencies. Either the modelling interface was poor, the tools themselves were too complicated (too expansive and complex to learn), too expensive or a combination of the three. We also found that many designers did not like using Revit for concept design work preferring to use Sketchup (Revit being a predominantly technologists tool).

As architects (and Revit & Sketchup users) we need to simplify our workflows to allow the front end designers to capture and manipulate clients requirements and develop concept models in their tool of choice (Sketchup), collaborate at the same time with cost estimators, and for this information to be transferable to Revit (or Archicad, or any IFC certified development tool) for detailed design development once concept work was complete.

As no suitable software tool existed, we set about the task of building one which came to be known as Quarter 1 (as in a concept development tool for the first quarter of a project).

3. RESULTS & DISCUSSION

Since one of the principal issues with the existing available front end tools is the lack of a suitable drafting interface we decided to start with the concept architects tool of choice which is Sketchup. So that part of the problem was easily solved.

Sketchup has an open API and a manageable scripting language in Ruby script so it is 'simply' a matter of coding the functionality we required into sketchup. Sketchup, whilst quite a simple drafting tool, is not quite the 'dumb' tool people take it for. It has functionality in so far as one object (a cube for example) 'observes' its relationship to another object. So, a suitably experienced scripter, armed with the necessary algorithms, can give some quite complex features and functionality to Sketchup.

Sketchup is not without fault and the current IFC exporter is woefully inadequate. So, in order to gain export functionality in IFC so that data and geometry can be successfully exported and then imported into other BIM authoring tools, we needed to write a new IFC exporter for Sketchup.

The result of the process is a plug in for Sketchup (Quarter 1) built of some 20,000 lines of code which gives us the following functionality.

1 Gathering Clients Information and Developing a Spatial BIM

We can automatically gather, manipulate and schedule spatial requirements for projects from a spreadsheet or 'on the fly'. A spatial BIM.

2 Apply Cost Information to a Spatial BIM

Early project cost build-ups can be achieved based upon the simplest of spatial information.

3 Use the Spatial BIM for Energy Performance Based Design

A spatial BIM can be used to inform the earliest architectural design decisions on such matters as building orientation, facade glazing (solid and void), solar shading, daylight analysis and comparisons between building energy in use by passive and active building fabric and services options. Rationalising the design process to bring forward this principle to the concept design stage saves vast amounts of time, resources and money.

4 Use the Spatial BIM for Data Collation

How you can use a spatial BIM to gather data for later use. For example (in the UK) populating the BIM with COBie 1 data and later exporting as a COBie spreadsheet.

5 Develop the Spatial BIM into a Concept Design

How to develop spaces into a concept architectural design and how these can be reviewed (for massing studies for example) in Google Earth and how building elements can be simply classified for later functionality and export.

6 Refining Cost Estimates

Use classification of the concept model, which linked to cost data (e.g. BCIS in the UK) can be used and manipulated to form simple Elemental Cost Plans.

7 Export Information for Detailed Design in other BIM tools

Utilise the 'One Key' principal to move information and data on from concept design to detailed design development in the more complex mainstream BIM tools using IFC.

4. CONCLUSIONS

4.1 Conference Topic Area

- BIM Technology and Interoperability
- Architecture and Engineering

4.2 Learning Objectives

- Gathering and manipulating clients requirements and developing the Building Brief / Programme digitally
- Managing project cost from inception of the design
- Refining design processes and saving time
- Develop design concepts with reusable geometry and data via IFC

4.3 Target Audience

- Architects
- Quantity Surveyors
- Owners / Public & Private

The development of Quarter1 has allowed Metz to streamline its workflows, give clients better and earlier control of their spatial requirements and bring project cost into the early stages of the design process.

4. Social Events