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Project cost management with 5D BIM

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Abstract

This paper explores the practical issues and constraints faced by project cost management professionals in the implementation and effective utilization of the various software, technologies and tools that are now available in the rapidly developing Building Information Modeling (BIM) sphere. BIM and its allied digital technologies and tools provide enormous opportunities for project cost management professionals to dramatically improve the quality, speed, accuracy, value and sophistication of their cost management services and therein ensure their future as key players in the BIM world. However, the profession has generally been slow to embrace and evolve with the full potential that these technologies can provide. There is now considerable momentum building as firms realize they have to embrace these technologies and see competitors seizing market advantage through developing expertise in the field. The purpose of this paper is to explore the issues faced by firms and to identify successful practices, procedures and strategies that firms are implementing. The research methodology for the paper is based on detailed interviews with Quantity Surveying firms in Australia. The results show that the interviewed firms are spending a lot of time and effort in developing their expertise and that there was a consistent pattern in relation to the main issues and problems and what was needed to be successful. The greatest issues related to the quality/comprehensiveness of the BIM models, difficulties with designers not providing full access to the models and software/standards compatibility issues. Successful strategies were clearly based on strong commitment and leadership from company directors and positive approaches to dealing with the issues and challenges faced. The paper concludes with a range of recommendations and strategies to help address these issues.

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Keywords: 5D BIM, Project Cost Management

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1. Introduction

Building Information Modelling (BIM) provides both opportunities and challenges for the project cost management profession. As quantification increasingly becomes automated and BIM models develop the role of the project cost manager will need to adapt accordingly to provide more sophisticated cost management services that incorporate 4D time and 5D cost modelling and sharing cost information/data with the project team as part of the BIM integrated project delivery approach. The RICS (2014) contend that BIM provides project cost managers with the opportunity to spend more time on providing knowledge and expertise intensive advice to the project team - the automation of processes such as quantification will substantially reduce time spent on technical processes and will provide more time and the digital tools for higher value-added and more sophisticated cost management services. Mitchell (2012) describes the importance for the project cost management professional to embrace the 5th dimension and become key players in the BIM environment – the '5D Project Cost Manager'. Muzvimwe (2011) supports this notion and describes the value of the cost manager in being able to simulate and explore various design and construction scenarios for the client in real time through having their cost data and quantities integrally linked in the live BIM model. This certainly raises the value of the cost management service but is dependent on the cost manager having BIM capability/expertise, sharing their cost data in the model and having the experience, expertise and intuition to analyse and critique the information that is being generated by the model.

2. 5D BIM Implementation

The development of 5D (Cost) capabilities is gaining momentum and leading edge project cost management firms are starting to realize the competitive advantages by embracing this 'new-age' approach to cost management. A major catalyst for the profession using this technology occurred in 2008 in the United States. The Association for the Advancement of Cost Engineering International (AACE), the American Society of Professional Estimators (ASPE), the United States Army Corps of Engineers, the General Services Administration (GSA) and the National Institute of Building Sciences (NIBS) formed an agreement to work together to solve cost engineering related problems for the facilities industry under the buildingSMART Alliance. The purpose was to develop systems and protocols for collaboration and coordination of cost engineering and estimating through the project lifecycle. 'The consortium continues to adjust to, and coordinate with ever-changing standards, so that the process of extracting and processing the 5D (cost) information from the BIM model is clearly defined, especially as the design evolves' (ConstruchTech 2013, p.1).

In 2012 the Royal Institution of Chartered Surveyors (RICS) published new guidelines known as the Black Book (Quantity Surveyor and Construction Standards) and New Rules of Measurement (NRM). The Black Book is a comprehensive suite of documents that defines good technical standards for Quantity Surveying and Construction. The New Rules of Measurement suite provides a common measurement standard for cost comparison through the life cycle of cost management. *"The suite has been developed as a result of industry collaboration to ensure that at any point in a building's life there will be a set of consistent rules for measuring and capturing cost data, thereby completing the cost management life cycle and supporting the procurement of construction projects from cradle to grave. A better understanding of costs during the construction process will increase certainty for business planning and support a reduction in spending on public and private sector construction projects in the long run"* (Property Wire 2012, p.1). The New Rules of Measurement are integrally linked with BIM and enables a consistent approach to estimating and cost planning within BIM platforms. The RICS are currently looking at developing international standards in collaboration with other kindred associations and industry. The RICS have also recognized the need for global guidance for companies in terms of BIM implementation. They recently published a comprehensive 'International BIM Implementation Guide' for construction professionals and contractors that includes specific guidance for project cost managers (RICS 2014). They note that *"as the industry takes hold of this new future it is essential that organisations and individuals are not flying blind but have information to plot out a change plan and BIM implementation trajectory both for now and indeed a 'future wise' longer term digital strategy"* (RICS 04, p.1)

The extent of firms effectively implementing 5D technology is difficult to gauge. An innovative project cost management firm in Australia provides a good example of what is starting to happen. Mitchell Brandtman are a medium sized quantity surveying firm in Australia that market their firm as '5D Quantity Surveyors and BIM Advocates and Specialists'. Their Managing Director, David Mitchell, contends that the modern day cost manager should be a 5D cost manager utilising electronic models to provide detailed 5D estimates and living cost plans in real time. Mitchell believes that the cost manager provides greatest value through their cost planning role at the conceptual front end stages of a project by providing cost advice and estimates on various design proposals and then refining those estimates as the design evolves. Using traditional 2D approaches this cost planning advice takes considerable time and inhibits rigorous comparative analysis within the allocated time frame for the design development process (Mitchell 2012).

Mitchell argues that the *"5D Cost Manager can do this extremely quickly, an endless number of times and in a complexity of combinations. A 5D Cost Manager can also re-estimate the developing design an endless number of times providing feedback on the estimate variances and corrective suggestions"* (Mitchell 2012, p.4). Mitchell (2012) refers to this as the 5D 'Living Cost Plan'. He argues that these modern techniques can be used within traditional frameworks but that it is the behaviour and how the technology is used that is more important than the software.

Research into 5D BIM and the role of the project cost manager is also gaining momentum (Wong et al. 2011, Cheunga et al. 2012, Thomas 2012, Zhou (2012), Olatunji (2010) and Frei et al. 2013). This emerging research correlates with the emerging nature of 5D BIM implementation in the construction industry.

3. Research Methodology

The research methodology adopted for this study was detailed industry interviews with medium to large quantity surveying firms in Australia. The quantity surveying firms interviewed comprised five firms (three medium sized firms with 20-30 employees and two large firms with 30 plus employees). The firms were located in NSW and Queensland. Four of the firms had experience with the use of BIM and automated quantities whilst the other firm, who primarily produces bills of quantities, interestingly had undertaken a considerable amount of research and trialling of BIM/automated quantities but has currently decided to remain using traditional approaches until the core issues surrounding the technology are addressed. This provided a good contrast to the other firms who are utilizing this technology. The interviewees were asked a range of questions relating to the issues, problems and benefits associated with the implementation of BIM and automated quantities. The following provides a summary of the main findings

4. Research Findings

4.1. Collaboration With Designers & Development of Trust

Architects, engineers and other design consultants are typically reluctant to provide full versions of their models to quantity surveyors, contractors and the like. There are a range of reasons with the main one being what will be done with the models and the potential liability of the designer. Many designers will only provide limited versions of their models to contractors and quantity surveyors for 'information only'. Some cite intellectual property reasons but this flies in the face of the concept of BIM (sharing information as effectively and efficiently as possible) – the underlying reason is typically potential liability. A common thread from the interviewees was the importance of establishing strong collaborations with designers, gaining their trust over time and showing the value that that collaboration can provide for all parties. For example, as more detail is provided quantity surveyors have more scope to properly interrogate the model and identify errors/omissions/clashes which can be reported back to the designer for rectification. This has always been one of the traditional roles of the quantity surveyor in the 2D world and there is no fundamental difference in the BIM world.

This collaboration should extend to explaining to designers the information/data that the quantity surveyor needs, in what form and how the model can be improved. It is important that the quantity surveyor can clearly articulate what they want and explain the benefits to the designer in providing such. Ideally the quantity surveyor needs the native files from the model.

These requirements will change as the project evolves. For example, the information that the quantity surveyors requires from the model will vary considerably between the conceptual design stage, the cost planning stage, the detailed estimating/Bill of Quantities stage, the construction stage and the facility management stage of a project

One firm described their practice of a 'brainstorming interrogation' of BIM models for new projects. This may typically range from a few hours to a few days. They compile their team of experts to interrogate the model to identify issues, problems and information required. The results are then fed back to the designers/modelers for attention. The objective is to identify issues early and address them early.

4.2. BIM Data & Information

To fully encapsulate the potential benefits of BIM models, the models need to be information rich with comprehensive and accurate data. This requires considerable time and expertise on the part of the BIM modelers and BIM team. On many projects the BIM model falls well short of its potential due to incomplete/inaccurate data. The reasons for this are numerous but the main reasons evolve around whether the design fees include allowance for the input of fully comprehensive data and whether the BIM team have the expertise/knowledge/information to input the necessary information into the model. Many clients do not see the value in paying the necessary fees for comprehensive models or may not have sufficient knowledge/advice to know whether this has been achieved.

One quantity surveyor noted that he knew of an informal BIM forum for young BIM modelers sharing information on how to develop 'dumb' BIM models quickly that give the appearance that they are workable models and can quickly satisfy their clients' requirements. Then it will typically be the rest of the project team (contractors, subcontractors, quantity surveyors and the like) that need to work with the inadequate models and develop the further information required for construction.

4.3. Quantification

Four of the firms interviewed used automated quantities software to prepare quantities on their projects – two firms used this software extensively particularly in the cost planning stages whilst the other two firms used such software in a limited capacity. The other firm, who primarily prepares Bills of Quantities at tender stage, rarely used automated quantities software as they felt that the quality and the accuracy of the BIM/3D models provided to contractors at tender stage was not sufficient to be able to rely on the quantities that may be automatically generated.

The firms utilizing automated quantities used both proprietary and in-house software with the CostX program the most commonly used program. The CostX program is now the most widely used software of this type in Australia and is now used in over 40 countries around the world (Exactal 2013). The CostX program and the in-house programs were all capable of linking in with BIM models. The firms all agreed that they were on the 'automated quantities' path and that this would continue to develop as their own expertise and the software improved. The main issue that they found was in the quality of the electronic documentation (be it 2D, 3D or BIM models). The quality of documentation is critical to the development of accurate quantities and this issue has existed long before the introduction of electronic documentation. In the traditional 2D paper based days interrogation of the drawings and queries to correct design and information errors and inconsistencies was a normal part of the measurement process. The firms stressed that nothing has changed in the new electronic environment. The documentation still needs to be checked for errors and inconsistencies.

The new problem though is that it is more difficult to check the documentation accuracy despite advances in clash detection in BIM models. In the 2D days measurers would spend days and weeks measuring and 'absorbing' the project information in great detail. In the electronic 3D environment far less time is spent measuring and 'absorbing' and understanding the documentation details. There is also a new breed of young quantity surveyors who don't have that solid fundamental training in 2D paper-based measurement and may lack the experience and expertise to identify problems in CAD/BIM models as they might have done in the 2D environment. This leads to the major problem of not trusting the automatic quantities produced due to quality issues with the model. Problems may also occur where quantity surveyors are not fully conversant with the automated quantities software. This requires experience, expertise and intuition to be able to identify problems with the quantities produced.

The firms only use automated quantities to the extent that is feasible – whilst ideally suited to cost planning measurement there are still limitations with more detailed measurement for Bills of Quantities, Builders Quantities and other detailed estimating requirements. Automatic quantities will also only reflect what is detailed in the model – the need to identify information and quantities not in the electronic model is critical. It is also of note that with all of the interviewed firms a considerable amount of measurement is still done via traditional means (i.e. not automated quantities) particularly with respect to detailed measurements for Bills of Quantities and Contract/Claims Administration. All firms saw automated quantities as a 'journey' as they evolve with the technology and use it where practical and useful.

4.4. Quantity Surveying Tasks & Deliverables

Mitchell (2013) contends that the 5D objective during design is to create a living cost plan that provides a transparent framework for making early cost decisions. The living cost plan must be able to be revised and shared (on a weekly / fortnightly / or monthly cycle) using the current model information. The 5D objective during construction is to also provide a transparent framework for letting and administering construction contracts. The model map which created the cost plan becomes more detailed as the model Level of Development (LOD) progresses to become the basis for quantity take-off for letting and tendering, the valuation of variations, change orders and progress payments during construction and replacement work during operation of the building. The 5D objective on completion is to create a cost integrated 'as built' model that can be synchronised with the FM system to transfer replacement costs, base dates, expected and effective lives, estimated running and maintenance costs.

4.5. Clients

All interviewees felt that there is a need for clients, both private sector and public sector, to drive the development of consistent modelling standards. The public sector has a key role to play to provide the necessary leadership for effective implementation. However, the interviewees consistently cited the lack of national government leadership in the field in Australia. Many felt that government were largely not interested and preferred to leave it to the private sector to move the industry forward. Some also cited the lack of expertise within government client bodies due to the now long-standing practice of outsourcing services to the private sector.

4.6. Education & Training

Education and training requires substantial time and cost commitment from quantity surveying firms. Many interviewees identified the need for universities to help supplement this training so that graduates enter the industry with at least foundation knowledge in the BIM sphere and use of associated software and digital tools.

The interviewees described a range of approaches to education and training in their workplace. One firm noted their practice of peer review at the end of each project. The work of the team on each project is reviewed by peers at the end of the project to identify BIM issues/problems, success factors, failure factors and lessons learnt.

Most interviewees expressed concern about the issue of younger staff that may be proficient in the use of BIM models and associated software but lack fundamental knowledge and experience in the core competencies of the profession (construction/services technology knowledge, measurement principles and the like). Conversely, experienced older staff that struggle with this new technology. One firm cited their practice of teaming up younger/older staff members wherever possible so that they can work together and help overcome their respective deficiencies in knowledge/expertise and ultimately lead to long term continual improvement amongst their staff.

Certification was also raised. Certifications such as the 'Certified Practicing BIM Professional' will also help to develop professional understanding, skill and knowledge. This could involve certification of both individuals and companies. Examples cited included CanBIM from Canada. The CanBIM Certification Program for individuals is a tiered certification program providing a benchmark for individuals to be certified to nationally standardized and recognized levels of BIM Competency and Process Management (CanBim 2015).

5. Future Strategies & Directions

5.1. Main Issues

The RICS (2014, p. 62) highlighted the following main issues facing project cost managers:

- QS professionals receive models developed by other project team members and are expected to perform their tasks using these models.
- Given that the models are developed by other project team members, the first important task that QSs have to undertake is to review the model for accuracy and information richness. Many instances have been reported where the model does not have the required information to allow model-based measurements and quantity take-off.
- It is important for the QS to ensure that the automatic model-based measurements and quantity take- off are compliant with locally accepted standard methods of measurements.
- Classification systems adopted by the project team may have an impact on the work processes of the QS. Commonly adopted classification systems are RICS' NRM, OmniClass Construction Classification System, ICE CESMM, MasterFormat, UniFormat and CPIC Uniclass.
- The LOD of the model must be clearly understood by the QS so as to ensure that cost planning is in accordance with the level of information that is available in the model.
- Models can change frequently in the BIM environment. This has both positive and negative connotations. QS professionals/firms are able to provide better cost planning information to clients due to the model-based measurement and quantity take-off. However, frequent changes may disrupt the workflow normally expected by QSs.

In addressing these issues the RICS (2014, p. 64) suggest that following broad structural changes may be needed: "*broader vision and behavioural changes from all stakeholders to collaborate on the BIM platform with a 'whole of system' and a 'whole of industry' approach; capacity building, education and training for BIM implementation; better value proposition for all stakeholders (including the articulation of the value proposition); development of national standards and guidelines; investment in research and development; participation of the academic community in updating curricula; process- and people-driven change and not technology-driven change; and a life cycle view for BIM implementation with strong integration with supply chain and asset management"*.

5.2. BIM Modelling Standards for Measurement

The variance in modelling standards remains a big issue for project cost managers. The lack of consistent modelling standards requires quantity surveyors to adapt to a range of approaches – this leads to obvious inefficiencies and wasted time. Project cost managers attempt to reduce this problem by developing collaborative relationships with designers as outlined earlier but this is a small piecemeal approach to an industry wide problem.

The development of national BIM modelling standards was viewed by interviewees as one of the most important factors in terms of successful long term BIM implementation. Ideally, the development of a global BIM Modelling Standard for Project Cost Managers/Quantity Surveyors would be the best approach. The International Cost Engineering Council (ICEC), the RICS, the European Council of Construction Economists (CEEC) and other professional associations are in the early stages of the development of a global International Construction Measurement Standard (ICMS). The purpose is to develop international standards through input and ownership by professional cost management associations around the world that are recognized by world bodies and national governments. There is much potential for this initiative to extend to the development of global BIM Measurement Standards and concomitant BIM Modelling Standards. Such a global initiative would have considerable potential influence on BIM software vendors and the industry generally. A few firms cited the UK BIM Standard 1192 (UniClass 1.4) as a good model that could form the basis of a global standard. Currently BIM software vendors largely determine modelling standards.

5.3. Level of Development (LOD) Specification Standards

BIM specification standards during the various stages of development of a project are important for project cost managers and other construction professionals to assist them in defining their information requirements during these various stages. The BIM Forum (2013) have developed a Level of Development (LOD) Specification that has potential global application. It is a reference that enables professionals to specify and articulate with a high level of clarity the content and reliability of Building Information Models (BIMs) at various stages in the design and construction process. The LOD Specification utilizes the basic LOD definitions developed by the American Institute of Architects. It defines and illustrates characteristics of model elements of different building systems at different Levels of Development. This clear articulation allows model authors to define what their models can be relied on for, and allows downstream users to clearly understand the usability and the limitations of models they are receiving (BIM Forum 2013, p.8). The intent of this Specification is to help explain the LOD framework and standardize its use so that it becomes more useful as a communication tool. It does not prescribe what Levels of Development are to be reached at what point in a project but leaves the specification of the model progression to the user of this document. To accomplish the document's intent, its primary objectives are to help teams, including owners; to specify BIM deliverables and to get a clear picture of what will be included in a BIM deliverable; to help design managers explain to their teams the information and detail that needs to be provided at various points in the design process and to provide a standard that can be referenced by contracts and BIM execution plans. (BIM Forum 2013, p.8).

5.4. Modeling Existing Buildings

New buildings only account for approximately 1 – 1.5% of the total building stock. Considerable work is being done on the modelling of existing buildings. This has important ramifications for the facility management and refursbishment/retrofit markets. Project cost managers need to get involved with this. The RICS (2014, p. 25) comment that '*with the proliferation of BIM there is now a need to capture as-built information, especially for large-scale retrofit and renewal projects. In these situations it is useful to start with the base digital model of the facility as it exists on site. This is now possible by linking laser scanning and 360-degree video or camera vector technology*'.

5.5. Data Management

The RICS (2014, p. 25) also contend that the large volumes of data that can be created in the BIM process need to be adequately managed. *"To succeed in large-scale BIM projects, data management software should be used. Data management technology allows the modelling process to be connected with extended, dispersed and remote team members. Access control and security along with version control on the model and associated files is ensured through this technology"*.

5.6. Evolving With Digital Technologies Generally

Big Data is also an area that project cost managers should also embrace and evolve with. The 'Internet of Things' shows that in 5 years there will a 30 fold increase in devices connected to the internet. The future explosion in the number of intelligent devices will create a network rich with information that allows supply chains to assemble and communicate in new ways and will significantly alter supply chain leader information access and cyber-risk exposure (Gartner 2014). The information from these devices will be fundamental to Big Data and what can be done with this information. These transitions will affect how professionals behave in the future. Knowledge/possession of the data will have no value – the real value will lie on how this data is interrogated and interpreted.

Project cost managers are increasingly dealing with more connected, intelligent and demanding clients. The 'Internet of Things, cloud computing, cloud-based collaboration, crowd sourcing, robotics, prefabrication, sustainability and the like are all areas that professionals in the industry need to evolve with and be part of.

6. Conclusion

The full potential of BIM models is generally not being achieved. Objects in models commonly lack the substantive data that is required for project cost managers and other construction professionals to fully reap the benefits the model has the capacity to provide. This requires comprehensive and accurate data to be input by sufficient personnel with the necessary knowledge, experience and expertise and for adequate fees to be provided to ensure that this occurs. The key parties that need to invest in this data input are clients, developers and contractors. National and/or global object libraries and modelling standards also need to be developed to facilitate this. These remain big issues for the industry and impact directly on the ability of project cost managers to fully harness the potential of BIM.

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