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ScienceDirect

Procedia - Social and Behavioral Sciences 119 (2014) 475 – 484

Procedia
Social and Behavioral Sciences

27th IPMA World Congress

BIM & the 5D Project Cost Manager

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Abstract

This paper examines the global issues related to the role of project cost management professionals in the implementation and evolution of Building Information Modeling (BIM) in the construction industry. The paper is based on a review of current industry trends and issues with BIM implementation and detailed interviews with quantity surveying firms in Australia. BIM involves more than just 3D modelling and is also commonly defined in further dimensions such as 4D (time), 5D (cost) and even 6D (as-built operation). 4D links information and data in the 3D object model with project programming and scheduling data and facilitates the simulation analysis of construction activities. 5D integrates all of this information with cost data such as quantities, schedules and prices. 6D represents the as-built model that can then be used during the operational stages of the facility. This paper explores the importance for project cost management professionals to be integrally involved across all project phases and to embrace the 5th dimension to become key players in the BIM environment – the '5D Project Cost Manager'. The literature review and industry interviews will examine the issues associated with this and will identify leading edge best practices in the field by professional project cost management firms. The paper concludes with the findings that the greatest value with the modern day project cost manager lies in their ability to be 5D literate and to be able to utilise electronic models to provide detailed 5D estimates and living cost plans in real time.

Selection and peer-review under responsibility of the IPMA.

Keywords: Project Cost Overruns, Project Cost Management, Quantity Surveying, Cost Engineering

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1877-0428 © 2014 The Authors. Published by Elsevier Ltd.
Selection and peer-review under responsibility of the IPMA.
doi:10.1016/j.sbspro.2014.03.053

1. Introduction

The main professional disciplines providing specialist project cost management services around the world are cost engineers, quantity surveyors, construction economists and project managers. Quantity Surveying is a profession with origins in the United Kingdom and is a professional title recognised mainly in Commonwealth countries. Cost Engineering is the term mainly used in North and South America, China and some parts of Europe. Construction Economist is used in some European countries and in other parts of the world as an alternate descriptor for the service. In other regions, particularly in Europe, these three professional titles are not recognised with cost management services largely carried out by Project Managers as part of their suite of services. But cost management is not the exclusive preserve of these professionals as few countries require official registration to practice as a professional in the field. A range of other professionals and technicians also carry out these services. For the purposes of this paper the term 'project cost management' will be used to describe this professional field.

Building Information Modelling (BIM) and automated quantities technologies provide 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 (2012) contend that BIM does not simply involve the use of new software/technology but rather that it requires a different way of thinking and a new approach to project procurement and delivery. Fundamental to this is the need to move from the traditional approach of project participants working on separate information pools typically with different and incompatible software technologies to a totally integrated common platform whereby participants can share and work on the same information – the BIM model is the primary tool for the whole project team..

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 dependant 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.

This paper will explore the opportunities and challenges that the profession faces in evolving with this technology and becoming key players in the virtual project team. Whilst there is considerable literature and research in the BIM field there is a dearth of literature and research from the perspective of the project/cost manager (Karmeedan 2010, Olatunji et al. 2010, Wong et al. 2011). This paper therefore contributes knowledge to the profession by examining implementation issues with a particular focus on the cost aspects of the BIM model. This is important not only for project/cost managers who provide cost management services but also for those parties that engage them to provide these services.

2. Literature Review

2.1. BIM Terminology

A variety of terminology is used to describe BIM, subsets of BIM systems and allied technologies. Aranda-Mena et al. (2009), Goucher & Thurairajah (2013), Brewer et al. (2012) and BuildingSmart (2012) have highlighted the need for consistent definitions and terminology to address the considerable confusion and misunderstanding about BIM in an industry still grappling to evolve with this technology. A widely cited definition of BIM is provided by the US National Institute of Building Sciences - *'a digital representation of physical and functional characteristics of a facility...and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition'* (NIBS 2007, p. 21).

The various subsets of BIM are commonly described in terms of dimensions – 3D (object model), 4D (time), 5D (cost), 6D (operation), 7D (sustainability) and even 8D (safety). Eastman et al. (2011) and Karmeedan (2010) have defined this multidimensional capacity of BIM as 'nD' modeling as it has the capacity to add an almost infinite number of dimensions to the Building Model.

Kameedan (2010, p. 285) provides the following explanations of the various dimensions. *'4D is a planning process to link the construction activities represented in time schedules with 3D models to develop a real-time graphical simulation of construction progress against time. Adding the 4th dimension 'Time' offers an opportunity to evaluate the buildability and workflow planning of a project. Project participants can effectively visualize, analyse, and communicate problems regarding sequential, spatial and temporal aspects of construction progress. As a consequence, much more robust schedules, and site layout and logistic plans can be generated to improve productivity. Integrating the 5th dimension 'cost' to the BIM model generates the 5D model, which enables the instant generation of cost budgets and genetic financial representations of the model against time. This reduces the time taken for quantity take-off and estimation from weeks to minutes, improves the accuracy of estimates, minimizes the incidents for disputes from ambiguities in CAD data, and allows cost consultants to spend more time on value improvement. 6D allows extending the BIM for facilities management. The core BIM model is a rich description of the building elements and engineering services that provides an integrated description for a building. This feature together with its geometry, relationships and property capabilities underpins its use as a facilities management database. Incorporating sustainability components to the BIM model generates 7D models, which enable designers to meet carbon targets for specific elements of the project and validate the design decisions accordingly or test and compare different options. The 8th dimension incorporates safety aspects in both design and construction. In summary, BIM allows designers to more easily predict the performance of projects before they are built, respond to design changes faster, optimize designs with analyses, simulations and visualization, and deliver higher quality construction documentations'*.

2.2. BIM Implementation Trends

In Australia BIM use in the construction industry is not currently widespread and there has not been any government mandates to use BIM on projects of any note. But the past five years has since interest in BIM adoption intensifying as a result of a number of initiatives to engage and inform project stakeholders about the potential productivity gains and gaining competitive advantage (CIBER 2012). These initiatives include the development of Australasian BIM guides such as the 'National BIM Guide' by the National Specification (NATSPEC), 'National Guidelines for Digital Modelling' by the Corporate Research Centre for Construction Innovation (CRC-CI), the 'Australian and New Zealand Revit Standards' (ANZRS) and the BIM-MEPAUS guidelines and models. The 'buildingSmart' organisation (previously called the International Alliance for Interoperability) continue to play a major leading role in BIM development and implementation in Australia that includes establishing an 'Open BIM Alliance of Australia' that involves an alliance with a number of software vendors to promote the concept of 'Open BIM' (CIBER 2012)

North America and the Scandinavian regions are generally regarded as the construction industry leaders in BIM development and implementation (Wong et al. 2009). McGraw Hill Construction (2013) found that BIM adoption by project team professionals in the North American industry had grown from 17% in 2007 to 71% in 2012 which demonstrates that BIM is now in the mainstream in the industry. This indicates that this region is leading the way on a global scale. A major catalyst for this dates back to 2003 when the General Services Administration (GSA) established a National 3D-4D-BIM program through its Public Buildings Service (PBS) Office. As a major public sector client with approximately 8700 buildings across the United States this program has had a tremendous influence on BIM adoption thus demonstrating the importance of major client and government leadership for the industry (Building Smart 2012).

Brown (2008) also found that there was a significant increase in support for BIM in the United States following the publication of two major reports by the National Institute of Standards and Technology (NIST) that measured the cost consequences of inadequate interoperability in the capital facilities sector of the US construction industry. They estimated the annual cost burden to US$15.8 billion.

The Scandinavian region also has a strong BIM development and implementation track record. Government mandates for the use of BIM on government projects have provided further impetus in countries such as Finland, Norway, and Denmark. The Finnish Government have invested heavily in IT research in the construction industry since the 1970s (Granholm 2011). They recently released a Universal BIM Guide for the industry which is being heavily supported. The Finnish public sector is the key driver in BIM adoption with Senate Properties, a major government entity with a property asset portfolio of approximately 6 billion Euros, a major leader requiring BIM on their projects and undertaking many pilot and research projects. Across the industry BIM is used on 20-30% of government projects with predictions that this will increase in the near future to 50% (Koppinen & Henttinen 2012). In Denmark the Danish Enterprise and Construction Authority established a Digital Construction Program in 2007 that has been implemented by major government entities. The program requires that BIM is used on all projects over 5.5 million Euros with information exchanged using the Industry Foundation Class (IFC) format. A number of reports and guidelines have been produced to assist firms in meeting these requirements (Building Smart 2012). In Norway Statsbygg is the Norwegian government's construction and project management representative and requires the use of BIM on all public projects. The Norwegian government is a strong supporter of BIM and invests heavily in research and development (Granholm 2011).

In the United Kingdom the government has introduced a BIM implementation strategy for the UK construction industry that is considered by many to be the most ambitious and advanced centrally driven BIM implementation program in the world (HM Government 2012). The objective is to transform the UK industry into a global BIM leader in a relatively short space of time (Withers 2012). In May 2011 the UK Government Construction Strategy was published which detailed the government's intention to require BIM on all of its projects by 2016 through a 5 year staged implementation plan. BIM is seen as central to the government's objective in achieving a 20% saving in procurement costs (Cabinet Office 2011). This strategy has had a dramatic impact on the UK industry as firms scramble to develop the necessary technological capabilities to meet these requirements. This strategy has the potential to influence BIM implementation on a wider global scale as other countries take note of these developments. standards.

Singapore is also emerging as a world leader in BIM implementation. The Singapore Building and Construction Authority (BCA) have developed a strategy to have BIM widely implemented on public projects by 2015 (Granholm 2011). The government has also established a Construction Productivity and Capability Fund (CPCF) of S$250 million with BIM a key target. In 2000 the Construction and Real Estate Network (CORENET) program was established as a strategic initiative to drive transformation in the industry through the use of information technology. CORENET provides the infrastructure for the exchange of information amongst all project participants. The CORENET e-Plan Check system for development applications is a further initiative to encourage the industry to use BIM. The system enables architects and engineers to check their BIM designed buildings for regulatory compliance through an online 'gateway'. Singapore has adopted the Industry Foundation Classes (IFC) as the standard for BIM implementation (Building Smart 2012).

The main driver for BIM implementation is the potential economic benefits at both macro and micro levels. The business case for firms in the industry is becoming clearer and the economic benefits for government are increasingly being recognized.

2.3. BIM Implementation Issues

BIM implementation issues in Australia are not dissimilar to those experienced in other countries. The AIA (2010, p.2) highlight leadership as the key requirement. *'Leadership is required to move the AEC industry forward. Users of BIM are taking different approaches to solving the issues that are presented, and the resulting fragmented approach across the industry has made it difficult to capitalise on the considerable benefits of a coordinated approach based on trust, communication and commitment'.*

To this end government is widely cited as the key driving force for change and that leadership should stem from that level (CIBER 2012, AIA 2010). The AIA (2010) contend that the Australian federal government should provide the leadership to facilitate a coordinated approach across all state and territory boundaries.

The AIA (2010) also emphasised the need for industry and professional associations to be more proactive and to help lead the many changes required in the industry. They developed a series of key recommendations for BIM implementation which also provide insight into the industry issues:

- Leadership and coordination across the industry with government mandates for BIM use and industry/professional association partnerships to work together
- Industry skills development with coordinated approaches to training
- Multi-disciplinary approaches to education with universities and colleges providing BIM courses across disciplines and faculties
- Software compatibility development
- Client BIM awareness and education strategies (AIA 2010, p. 12)

A major industry BIM study into implementation issues in the United Kingdom came to similar conclusions. The UK Department of Business, Innovations and Skills (2011) developed a BIM strategy paper for the UK construction industry that has been widely referred to. They described it as a 'Push-Pull' Strategy. They contended that to enable effective BIM delivery the BIM information on the client side and the delivery side must be aligned both in terms of expectation and capability.

'Push' Element

This looks at the supply chain and methods to make it easier for them to make use of BIM approaches such as BIM more easily. There are many vendors in the market all with their offerings purporting to be the best BIM solution; there are many in the supply chain who are at differing points in the maturity curve, and all think that their flavour of BIM is the answer to all. There is also a dearth of guidance, training, materials and common processes available to offer consistent advice to the processes, data definitions or deliverables specifications. The proposal is package products, standards, guides and training to support clear simple delivery. Packages are identified by their maturity

'Pull' Element

This element of the strategy looks at the client 'Pull' and how the Government client and other clients should be very specific and consistent about what they specify. This includes the need to specify a set of information (data) to be provided by the supply chain to the client at specific times through the delivery and operational life of the asset. This would rely on the careful definition of what data deliverables would be needed and when and linking to the standards and specification process above. This data delivery would have the dual benefit of ensuring that complete information sets are delivered on time, enabling commercial checks and handover information delivery and consistent digital handover information is delivered, enabling access to the design, costs, carbon and performance of the asset' (UK Department of Business, Innovations and Skills 2011, p.5)

2.4. 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 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.

2.5. RICS Survey of BIM Implementation by the Quantity Surveying Profession

The RICS (2011) undertook a survey of BIM usage by Quantity Surveyors in the United Kingdom and the United States which is likely to be the most comprehensive survey of its type around the world to date. The survey provides a snapshot of the level of BIM adoption by the quantity surveying profession and the issues encountered that may well be applicable to many other countries in which quantity surveyors operate.

The survey was sent to 8,500 RICS members in April 2011 asking about their firm's engagement with BIM with 298 responses from quantity surveyors (156) and building surveyors (96). The following outlines the key findings from the quantity surveyor responses.

Only 10% of QS firms used BIM regularly with a further 29% having limited engagement with BIM. Accordingly 61% of QS firms had no engagement with BIM. For the QSs that were using BIM the most frequent use was for construction scheduling (14%) followed by the extraction of quantities and facilities/asset management (both 8%). Only 4% of QS firms regularly invest in BIM training and only 10% actively assessing BIM tools for potential adoption (RICS 2011.

This indicates that the QS profession in this region is not embracing BIM to the level that is needed. However, given that the UK government mandate for BIM usage was introduced at the time of this survey it would be interesting to see what effect this has had on QS firms since then. The biggest barriers for QS firms adopting BIM were cited as the lack of client demand, training, application interfaces and software.

3. Research Methodology

The literature review revealed that there has not been any current study carried out on the level of BIM adoption and implementation by the quantity surveying profession in Australia. Accordingly the research methodology adopted for this study was to undertake industry interviews with medium to large quantity surveying firms in Australia.

The quantity surveying firms comprised three medium sized firms (10-20 employees) and three large firms (20 plus employees). All of the firms had affiliated offices in Australia but focus was placed on the quantity surveying services provided by the home office. The firms were located in NSW and Queensland. Four of the firms (the three large firms and one medium sized firm) had experience with the use of BIM and automated quantities whilst the other two firms had limited experience with automated quantities and no experience with BIM on their projects to date.

The interviews were conducted individually with experienced quantity surveying practitioners from each of the firms and involved general discussions on the benefits and issues surrounding BIM and automated quantities implementation. The interviewees were asked a range of questions relating to the issues, problems and benefits associated with the implementation of BIM and automated quantities but scope was intentionally provided for broader discussion to identify issues beyond that perceived by the author. The interviews enabled a deeper interrogation and understanding of the issues than might be obtained via questionnaire surveys. The firms represented a good indicative sampling of medium and large sized firms in the Australian quantity surveying profession. This enabled the author to canvass issues, to investigate initiatives being undertaken and to identify future needs. The following section outlines the main findings derived from these meetings and discussions.

4. Research Results

4.1. Quality of the BIM Model

The quality of BIM models was the major concern. The use of BIM models require the input of vast amounts of interconnected data and information that is typically complex. Whilst BIM models have clash detection facilities there are limitations in terms of checking all information. Clients also need to be prepared to invest in the proper development of a quality model – often the limitations are brought about by consultancy fees that are insufficient to develop the model to the level required. The concept of 'Rubbish In Rubbish Out' certainly holds true for BIM models. The liability for the use of inadequate or incorrect information in the model is also a major concern.

4.2. Automated Quantities

All of the firms interviewed used automated quantities software to prepare quantities on their projects. Four of the firms used this software extensively particularly in the cost planning stages whilst the other two firms used such software in a limited capacity. The firms 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. They all agreed that there has been a significant increase in the use of automated quantities over the past few years within their firms.

4.3. Lack of Standards/Software Incompatibility

All of the interviewees note that the lack of consistent standards and software incompatibility along the project supply chain remains an issue despite great improvements in recent years. Fully integrated project delivery with multi-disciplinary project teams working on a single integrated and compatible BIM model is essential for the optimal use of BIM. The scope for this currently remains limited. The use of BIM is generally considered to be currently more suited to larger projects with larger clients and contractors who have the scope to demand that all project participants have the necessary technological capability and compatible software. Even then two of the interviewees spoke of working on BIM projects but effectively working outside of the BIM model due to incompatibility issues in terms of not only software but also standards and practices. This is also compounded by key parties in the project supply chain not meeting the capabilities required. All agreed that these issues will continue to improve but nonetheless are critical for successful BIM implantation across the industry..

4.4. Sharing Cost Data Information

The full implementation of BIM on projects involves the sharing of information amongst project participants. A quantity surveying firm's cost databases provide the foundation for the quality and value of the services they provide and can provide significant competitive advantage. Accordingly the concept of sharing this cost data with the project team is still being addressed by firms. Interviewees all noted that this is an issue not easily resolved but agreed that as BIM becomes more mainstream over time this concept will become a reality for firms – either share their data or not be involved.

4.5. Business Changes

The move towards BIM capability and expertise requires quantity surveying firms to re-evaluate and re-engineer their business practices. The interviewees all agreed that this is nothing new for quantity surveying firms who have typically had to adapt and rebrand their services to meet the changing demands of clients and the industry generally. A trend has emerged whereby the larger quantity surveying firms are forming alliances with other firms to form global management consultancy practices that provide services well beyond the traditional domain of the quantity surveying practice.

Nevertheless the business impacts of moving to BIM and automated quantities are significant. Whilst the software and technology does require significant up-front investment the greatest cost lies in staff training and development. Whilst the aim is for this to reap benefits and competitive advantage in the longer term these development costs are significant particularly in the current climate where market activity in many sectors of Australia are at relatively low levels and fee cost-cutting amongst quantity surveyors and other construction professionals is common-place. Many firms have limited financial scope to invest in current and future digital technologies and capabilities. The added complication is that the technology is always evolving and the interviewees commented that a lot of time and expense can be spent on software and training with uncertain outcomes. The 'pioneering' path can be high risk as firms become 'test pilots' for certain technology whilst their competitors wait in the wings to see if the 'testing' will result in commercial value and competitive advantage. But all interviewees agreed that the 'wait and see' approach is no longer viable for firms that want to be key players in the construction market particularly at the top end.

Cultural business change is another challenge for firms - changing the mind-set of staff to embrace and evolve with this new technology. This is seen by many firms as the significant inhibitor to major change – the conservatism and inability to adapt by staff members. However the interviewees commented that they have noticed clear shifts in attitudes in the past couple of years as professional staff realise that if they do not evolve with this technology and develop expertise they will be left behind. The younger quantity surveying generation moving into the profession are more amenable to digital technologies and change and in many ways represent a threat to more senior personnel resistant to change.

The issue here raised by interviewees was whether this younger QS generation are moving too quickly with this technology without developing fundamental QS competencies and skills. Traditionally young quantity surveyors would spend much of their time physically measuring and 'absorbing' project details and documentation. The more progressive firms are now getting their young QSs to use automated quantities software immediately but there is a question of whether they are moving too fast and are not developing the analytical and checking skills and competencies required to evaluate and critique the information being automatically generated.

4.6. Legal/Contractual/Insurance Issues

The legal and contractual issues relating to BIM projects are still being addressed and create considerable uncertainty for BIM participants. The interviewees agreed that this needs to be resolved before the full collaborative potential of BIM can be realised. This starts with clearly establishing legal ownership of the model and legal responsibility for errors and problems with the model through the whole life cycle of the model. The uncertainty over legal liability is also creating issues for insurers in the industry which has obvious implications for firms providing services on BIM projects. This creates uncertainty over insurance coverage and may lead to insurance exclusion for BIM projects.

5. Conclusion

The need for Project Cost Managers to embrace and evolve with BIM is inevitable but the rate of adoption and implementation remains to be seen. Government mandates to use BIM on public sector projects, such has occurred in the United Kingdom and the United States, would certainly accelerate BIM implementation by the profession should not be waiting until their clients require it. The longer firms delay their entry into the BIM and automated quantities world the further other firms with these capabilities will progress and add to their competitive advantage.

Rather than a threat, BIM and automated quantities technologies provide the profession with enormous opportunities to raise the value of their services to a much higher and sophisticated level. It is not simply about automatic quantities generation. The ability to simulate a range of design options with real-time cost advice and continue that real-time cost advice throughout the detailed design, construction and operational stages will arguably place the project cost manager at the top of the 'value chain' for project clients (or at the very least provide a 'must have' service for the client). It also places the project cost manager in a powerful position to maintain and control key information the virtual model and drive cost performance on projects.

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