SHAVING BIM: ESTABLISHING A FRAMEWORK FOR FUTURE BIM RESEARCH IN NEW ZEALAND

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ABSTRACT

This paper reviews and analyses issues relating to the uptake of BIM in the NZ construction industry. There have been few BIM applications in NZ; in particular, in post-construction phases like facilities management, there is none. The paper found that the three reasons why BIM has not been widely accepted and used in New Zealand are: the slow uptake by NZ construction companies; a lack of Kiwi-focused BIM initiatives (led by the government and industry bodies); and a lack of BIM-based building life cycle considerations. Therefore, the paper concludes that there is an urgent need for a joint research programme in NZ to develop a Kiwi-oriented knowledge base on BIM. Given the fact that all major research organisations currently have development plans in their pipelines, coupled with potential developments of the Christchurch City after the quake, it seems an ideal time to take a BIM-based research initiative in the country. This joint BIM- focused research programme should concentrate on construction management processes, including procurement management, contract management, information management, as well as post-construction aspects such as facility management.

KEYWORDS: Construction, BIM, Facility Management, Research.

INTRODUCTION

Building Information Modelling (BIM) is a dedicated information technology software designed to enable and support the interdisciplinary collaboration and communication between a variety of professional stakeholders that are involved in the construction process of buildings (Autodesk, 2011; Roberti and Buckett, 2012). Post-construction BIM software is positioned as information technology designed to support facilities management.

Although there has been substantial work on benefits of BIM for construction processes and the potential for BIM in the building industry is huge, there is a lack of BIM-focused research catering specifically to the construction market in New Zealand. Given the fact that all major construction management research organisations in New Zealand such as BRANZ, AUT and The University of Auckland currently have development plans in their pipelines, coupled with potential re-developments of the Christchurch City, it seems an ideal time to take a BIM-based research initiative in the country. A joint BIM research programme is hence needed in New Zealand. This programme should investigate opportunity to integrate construction management processes such as procurement management, contract management, information management, as well as the post construction aspects such as facility management in the development of new buildings. This is important because all of these facets are significantly impacted by the utilisation of BIM technologies and therefore need to be addressed through research.

EXISTING LITERATURE ON BIM

General Applications of BIM

In 2007, Suerman and Issa carried out a study to assess impacts of BIM on construction projects. This was a qualitative study with survey questions centred around impacts on six construction key performance indicators (KPIs): quality control (rework), on-time completion, cost, safety (lost man-hours), dollars per unit performed, and units per man hour. Survey results of this study showed that construction professionals felt that overall BIM-based approaches improve construction metrics compared to those without BIM. Specifically, the highest three ranking KPIs in order of most favourable responses were quality, on-time completion, and amount of work done per man hour. The second tier of favourable responses included overall cost and cost per work unit. Finally, only 46% of the respondents thought that construction safety was improved through BIM (Suermann & Issa, 2007).

Based on results obtained from the Suermann and Issa's (2007) study, Suermann (2009) evaluated construction projects through interviews and case studies at two U.S. Army Corps of Engineer (USACE) sites. In this study, quantitative results were compared with construction productivity obtained from the USACE database. Further, benchmarks similar to the surveys' KPIs were quantified and used in this study. The results showed that both BIM-based projects demonstrated statistically significant (favourable and unfavourable) performance differences when compared to the control dataset (Suermann, 2009). Although the two Suerman's studies showed that BIM can play a significant role in the construction industry, the context in which they were considered was restricted only to the construction phase. There was no consideration of phases prior to the construction stage, e.g. costing, procurement management, and supply chain planning during the construction stage, e.g. construction management, contract management and liaison processes between various project stakeholders. This is a significant gap if one is to promote BIM to the wider construction sector.

To overcome the shortcoming presented by Suerman's studies, there have been a number of quantitative-based BIM research initiatives taking place. For instance, Shen and Issa (2010) used BIM to evaluate the detailed cost estimates of a construction project. Moreover, in order to understand the cognitive details of the estimator, the study also tested and evaluated the compound impact of visualisation factor and aggregated calculation factor on the construction cost-estimating process (Shen & Issa, 2010). Specifically, two types of BIM Assisted Detailed Estimating (BADE) tools were tested in order to differentiate the impact of visualisation factor on estimating performance from the compounded impact of both visualization and aggregation functions. In Shen and Issa's study, four parameters (namely generality, flexibility, efficiency, and accuracy) were utilised to evaluate the performance results individually; then, a multi-attribute utility model was employed to evaluate the overall performance of BIM-assisted estimating versus that of the traditional estimating method on quantity take-offs. Overall, BIM-assisted estimate demonstrated better performance over traditional estimating methods for the entry-level user. Further, both the visualisation and aggregation functions of the BADE tool had significant impacts on performance of detailed estimate. Moreover, it was found that in complex estimating tasks, it is more advantageous to use BADE tools instead of traditional estimating methods. However, Shen and Issa's study was limited to a small number of test cases; as such its results might not be applicable to a broader construction industry due to problems in extrapolation and aggregation from a smaller sample to bigger sample sizes.

Still on using BIM for project costing, Sattineni and Bradford (2010) carried out a survey in the US construction industry. The study found that BIM was mostly used for visualisation, design and modelling of architectural models and for collision detection. Further, Sattineni and Bradford (2010) reported that 52% of survey participants used BIM for cost estimating. However, they concluded that the US construction industry would not fully employ cost estimates using BIM unless BIM could be shown to be more beneficial than current estimating methods. The finding is evidenced by the slow uptake of BIM by large US contracting organisations (Sattineni & Bradford, 2010). This is because big contractors tend to take on large projects; but due to a big communication gap that exists within the BIM framework between the designers and contractors, contracting organisations tend to face high levels of risk in large-scale projects. Consequently, big contractors tend to shy away from BIM. For smaller contractors, who tend to take on smaller projects, such risks can be manageable because the BIM information gap is not so big; besides, since BIM enhances visual and planning capabilities of these organisations, they tend to be more willing to embrace the technology than their bigger counterparts.

In addressing another aspect of project design, Tulk, Nour and Beucke (2007) focused on the application of BIM on project scheduling. It was noted that although 3D CAD modelling, estimating and schedules have been widely used in construction projects, they generally lack systems integration capabilities for accessing different information and/or providing appropriate change management support (Tulk et al, 2007). In order to improve the current situation and to support the informed decision making process, a BIM-based scheduling framework was proposed to provide analysts with a more efficient system than those currently available, including (Tulk et al, 2007):

- Improved communication between stakeholders
- Reuse of information across processes
- Scalability regarding project stage and related data maturity
- Allowance for a fixed software infrastructure per stakeholder even across projects
- External data exchange based on a neutral data structure
- More efficient and powerful linking between CAD, quantities and schedule
- Adaptability of CAD object granularity through an object splitting functionality

- Change management and versioning capability

Similarly, through a scheduling problem, but at a more technical sense, Moon, Kim, Kang and Kim (2011) investigated configuration methodologies of BIM functions in order to control project limitations. Considered specifically in the construction phase, Moon et al's (2011) study developed an active BIM system that capable of providing an integrated workflow. To do this, a module that could optimise project management data such as schedule conflict and work-space conflict, and a module that could assess risks associated with construction works were developed. These modules were integrated through a 4D CAD system. The result was an active BIM that could simplify data analysis and system operation process for managers using virtual object models. Further, the model could expand the active BIM-system to the life cycle of civil engineering projects (Moon et al, 2011). Taking Moon et al (2011)'s approach a step further, Feng, Mustaklem and Chen (2012) developed an information integration sphere (IIS) based on BIM. The aim is to provide a more efficient and effective information integration model. It was found that IIS could clearly identify data requirements of various stakeholders at different stages of the construction project. In short, by implementing of the IIS model, a construction management-based BIM model could be achieved. Feng et al (2012) concluded that since IIS was developed with BIM software, in the future it could be linked to the building's components and used to automatically generate data requirements and responsibilities for the lifecycle of the project (Feng et al, 2012).

It must be noted that all BIM-based studies discussed above tend to focus on, and belong to, the design and construction processes. There are many interactions between professionals and stakeholders at these stages. As an example, a project scheduler must consider inputs from various domains to estimate overall project duration and cost factors; the resulting construction schedule is then used by other professional groups for project management, procurement and logistic processes (Tulk et al, 2007). Ultimately, all such interactions culminate to critical project decisions being made. Therefore, there needs to be mechanisms in place to encourage integrations and/or collaborations between these parties in order to achieve project objectives. One of such mechanisms is BIM. Although design and construction stages have already and significantly benefitted from this technology, BIM, however, has not been extensively applied to all aspects of a construction project. These include client liaison, procurement, contract/logistic/construction and facility management which will be discussed in the next section.

Applications of BIM in Construction and Facility Management

Around the world, companies of all sizes and disciplines have increasingly employed BIM in their operations (Heller and Bebee, 2007; Autodesk, 2011; Roberti & Buckett, 2012). In the USA, it was found that the most effective BIM applications was for clash detection, fabrication, costing, scheduling and planning, with more and more companies exploring ways to further incorporate BIM into their business processes (Heller & Bebee, 2007). Further, when integrating BIM with other specialist software, quality coordination and quality control in such specialised area as medical can be vastly improved while risks can be detected early and eliminated in a timely manner. Due to this capability that BIM can offer to its users, many firms in the US would not do a design-build project unless it is done in BIM (Heller & Bebee, 2007).

Similarly in Australia, BIM has been used to investigate opportunities to increase productivity in the built environment (BEIIC, 2010). The BEIIC study covered major phases of building projects, including design, construction and operation. It was found that by using BIM, important project parameters such as time, cost, material consumption as well as carbon emissions can be significant reduced while quality can be significantly enhanced (BEIIC, 2010). Further, it was estimated that by moving to the BIM space, the Australian could improve its productivity by 6-9% and help produce additional economic benefits equivalent to AU$5 billion to Australia's GDP by 2025 (BEIIC, 2010). Also, BEICC (2010) noted that the increasing use of information technology would have a profound effect on all aspects of the built environment (including planning, design, procurement, construction and operation practices). The study therefore concluded that there is a compelling economic evidence for greater use of BIM in Australia.

In 2012, Cho, Lee, Lee, Cho, Kim and Nam applied BIM to the construction management process of the Honam high-speed railway in South Korea. This project consisted of 6 bridges, including an arch bridge, an extra-dosed bridge and 2 tunnels with a total length of 9.38 km; with construction work scheduled for 31 months. Here, a BIM-based construction management system was adopted to thoroughly control detailed costs and the construction process. Specifically, this system is made up of full-range 3D information models and web-based 5D system models with safety and equipment management modules. It was found that the BIM help the project achieve great efficiency. Further, the technology delivered higher productivity while reducing of materials, times, and costs in the construction phase (Cho et al, 2012).

A similar work was carried out by Arayici, Egbu and Coates in 2012. Here, Arayici et al (2012) investigated the benefit of BIM implementation in an architectural company. The study showed that the key management and communication problems such as poor quality of construction works, unavailability of materials, and ineffective planning and scheduling can largely be mitigated by adopting BIM at the design stage (Arayici et al, 2012). However, it must be noted that BIM implementation in this study was initiated by the architectural company; if BIM implementation were initiated by the main contractor, key benefits of BIM implementation could include other aspects such as health and safety, labour training, on-site communication, construction planning and monitoring.

In recent times, BIM has been applied to Facility Management (FM) activities. According to a number of authors, there has been extensive body of literature on how BIM is changing the way buildings are designed and constructed, but very small amount on whether it is changing how buildings are being operated and maintained (Autodesk, 2003; Autodesk, 2007; East and Brodt, 2007; GCCG, 2011). However, these studies have highlighted the fact that there is a lot of interest in the building industry surrounding the use of building information for facilities management. In particular, Autodesk (2007) found that along with the increased use of BIM for design, the owner/operator's use of the same building information for facilities management has become more commonplace and more anticipated. For instance, many US government agencies now require spatial program information from BIM for major projects receiving design funding in fiscal year 2007 and beyond; while professional bodies such as the American Institute of Architects (AIA) has considered modifying their contract documents to include BIM in the agreement structure. Applications of BIM to FM were successful demonstrated as in the case of the Sydney Opera House. According to Ballesty, Mitchell, Drogemuller, Schevers, Linning, Singh and Marchant (2007), Sydney Opera House's building standards were recently migrated to BIM. As a consequence, management processes could now be carried out much faster and more effectively because all stakeholders could share and reuse information more easily. Ballesty et al (2007) also made a number of recommendations for the FM industry, including the standardisation of BIM as an integrated information source for FM processes, preserving BIM data by improving Industry Foundation Classes (IFC) and employ commercial FM software systems using IFC data.

Successful applications of BIM in a wide range of areas in the private sectors have triggered interests from governments all over the world, with several countries starting to investigate BIM-based approaches to project procurement and asset management around 2000 (Heller & Bebee, 2007; Connaughton, 2011; GCCG, 2011; Morrell, 2011; Liu and Hsieh, 2012). As an example, the Taiwanese government is considering developing and using a BIM-based procurement framework for public work in the country (Liu & Hsieh, 2012). The report found that although the paper-based procurement system currently suits Taiwan' need, the proposed BIM-based procurement system could offer the Taiwanese government more benefits in the long run (Liu & Hsieh, 2012).

A similar initiative was carried out in Portugal in 2011. In their paper, Grillo and Jardim-Goncalves described an approach towards electronic public procurement of construction and public works in this country. The paper analysed the effects that Information and Communication Technologies (ICT) and BIM and Cloud Computing have on the efficiency of procurement systems. It was concluded that the combination of these technological approaches enable a full de-materialisation of the whole building or public works life-cycle. Further, public procurement could become more efficient and can introduce competitiveness in the market place (Grillo & Jardim-Goncalves, 2011).

Literature reviewed in this section has shown that there have been significant efforts around the world attempting to implement BIM to various management aspects of projects. And although BIM has been widely applied to construction management (in different areas), there has been only one application of BIM to facility management (the Sydney Opera House case). Therefore, there is an urgent need to investigate FM aspects using BIM.

BIM Education

Aside from literature discussing direct applications of BIM in the market place or in the government sector, there are many authors who focused attention on BIM training and education. Jin and Shin (2011) noted that although adequate BIM training has been recognised as the most important area for companies, there are many challenges facing BIM educators. This comes from the fact that in reality, BIM education is often given by BIM vendors and such training programmes are often given in the forms of instructional and/or educational seminars. Jin and Shin's (2011) research proposed a development of eduBIM as the first private BIM-based education system with open BIM library in Korea. Preliminary results showed that through the new BIM education process, trainee's work capability and communication abilities were enhanced for BIM collaboration.

As a part of joint-discipline collaboration, a prototype BIM-based educational module was developed in 2011 at the Departments of Construction Management and Civil Engineering, Colorado State University. The aim of this module was to teach students about the integrated nature of information used in design and construction of buildings. The module uses BIM to create an interoperable learning environment so students could enhance their academic experience by applying such concepts to BIM (Richards and Clevenger, 2011; Clevenger, Ozbek, Glick & Porter, 2011). There are many advantages for developing such an educational system based on BIM. First, such a system gave students opportunities to gain insight into industry practices to better prepare them for work on real projects. Second, this was a unique opportunity to link faculty and students across departments and disciplines. The visualisation and animation capabilities of BIM create an opportunity for students of different disciplines to develop a greater understanding of the geometric relationships and sequencing inherent to the construction process particularly within the context of an entire building (Richards & Clevenger, 2011). Finally, students had exposure to information that construction managers use such as cost, economy of size, and uniformity and how this information affects the constructability of the building. Such a collaborative learning approach creates a more holistic understanding of the construction process. Without this collaboration, students would not be exposed to extended applications of BIM since they fall outside the domain of their discipline. Clevenger et al (2011) concluded that despite its weaknesses, the module's interactive and visual nature nevertheless engaged a high level of spatial cognition and critical thinking among students.

DISCUSSIONS AND RECOMMENDATIONS

Discussion

As seen from the previously posited literature, BIM is a dedicated information technology software capable of supporting collaboration and communication between stakeholders in construction projects. However, there are suspicions and scepticisms in the NZ construction sector surrounding BIM's usefulness (Roberti & Buckett, 2012). These suspicions and scepticisms are understandable in such a traditional industry as construction. Besides, like any new technology in this industry, it will take time for BIM to be accepted. At present, however, the NZ construction industry and its clients seem to struggle to make BIM profitable. This is due to 3 principle barriers:

Slow BIM uptake in NZ

BIM has been predominantly driven by overseas user demand and software development. BIM implementation in New Zealand has therefore focussed on the 'me too' approach. Technology, techniques and processes are largely developed by being modelled on implementers overseas. Mainly these exemplars have originated in the US, the UK and Australia. In recent times, more investments have been expended and significant efforts have been made by NZ construction firms to try to implement BIM in their practices (Jasmax, 2010). Although this is a big step forward, NZ construction in general still lags behind its international counterparts. Moreover, with few companies currently using the technology, the influence of NZ construction on BIM's development seems insignificant.

On one hand, this slow uptake suggests that the learning curve for the industry is steep compared to traditional methods of communication. Therefore, significant assistance in the form of knowledge transfer capabilities and training is required to build up necessary experience and skills for construction professionals and organisations. On the other hand, the uptake of BIM technology can be boosted if its benefits can reach investors and/or client organisations. By nature these parties are highly influential; especially in large projects, owners are typically in a good position to demand BIM utilisation. They therefore represent an excellent driver of uptake of technology. Investors and clients therefore need to be informed of the benefits of BIM and ways to work it into contracts. Overseas experience have shown that investment risks around construction projects (to owners) can be significantly reduced by coordinated BIM utilisation between professionals involved (Ballesty et al, 2007; Liu & Hsieh, 2012). In New Zealand, Central and Local Government, along with Crown Research Institutes, have become aware that noticeable savings can be made by using BIM for public construction works.

The targeted savings that New Zealand clients are seeking to achieve is primarily within the construction process costs. As such the savings are mainly in the one-off costs of construction. From a perspective of BIM implementation, the logic of this emphasis, i.e. on process cost reduction, is problematic in New Zealand because it does not make a compelling case for BIM use. The initial costs of BIM set up (software purchase, personnel training etc) need to be recovered on a relatively small market throughput. The interoperability of contractors and subcontractors through being 'BIM capable' is currently limited in NZ, since not being 'BIM capable' at present does not present significant potential loss of business for these organisations. Consequently, most firms operating in NZ construction at present are not 'BIM capable'; and therefore most construction projects are not BIM-centric. The construction market remains largely populated by clients that procure infrequently and therefore still have not had compelling arguments made as to why they should require BIM rendering of design on new projects. In the context of New Zealand a classic chicken and egg situation is therefore extant.

No Kiwi-focused BIM initiatives

Overseas experience has shown that by having matured BIM frameworks in place, the construction sector in these countries can reap the benefits of this new technology (Autodesk, 2011). In particular, large property developers and professional companies can continue to attract and retain clients via their BIM-based services. Likewise, NZ construction is best served by a functional and mature BIM software market that competes on quality and services. However, currently in New Zealand, the general mantra for BIM development has been "piggyback where possible, tailored to New Zealand where needed or required" (Roberti & Buckett, 2012). This might not be a good strategy in the long run because of the fact that the NZ construction industry is different to that of many other countries in a number of ways:

1) New Zealand construction is relatively small compared to that of other countries. This comparison with those of similar geographical size (such as the UK or Japan) or with those in close proximity (such as Australia). The small size of NZ construction has both advantages and disadvantages. The main advantage being the relative rapidity of change being transmitted to all components of the economy. Conversely the entropy of the construction economy in NZ – the energy needed to make a change - through lack of capital and skills needed to drive change remains significant. Very simply NZ is prone to systemic inertia unless compelled to change through demand or legislation.

2) New Zealand construction has, in the past, been proud of its innovative nature, with many world-first buildings showcasing its achievements (Massey University, 2012; ForsythBarr Stadium, 2012). As a result, there is a degree of resistance for change within the industry. This is based on the idea that NZ is doing very well, why change a 'winning' formula?

3) There is a well-known concern within the NZ construction industry about the slow transfer of experience and knowledge from current construction and design experts to the next generation (Roberti & Buckett, 2012). Moreover, there are fears that the use of information technology, especially BIM, may further exacerbate this problem because young professionals trained in the virtual environments may lose affinity with the practical reality of building sites and real-life behaviour of materials.

In spite of wide-spread advances in BIM systems and protocols around the world, there remains a lack of Kiwi-focused BIM development. However it seems apparent that NZ construction will have to evolve rapidly if it does not want to lose its competitive edge. There is starting to be a recognition that the cosy NZ market, with construction costs reportedly as much as 30% than the comparable Australian industry, is leaving itself open to drawing in major international competitors. The logic is brutal and yet immutable. Once the value of technological capability is greater than the supernormal costs of mobilising to the geographically remote NZ market, NZ companies will lose their captive clients.

Particular emphasis in Kiwi-focussed BIM will be the need for it to include quality standards and material performance information tailored specifically to New Zealand conditions. The remaining question is therefore whether companies in the Private sector are going to wait for the Public sector to take the initial developmental risk. Alternatively whether BIM benefits, as demonstrated by applications elsewhere, are compelling enough for them to take the initiative. Overseas experience has shown that when organisational barriers are overcome, larger construction projects increase their productivity by utilizing BIM. Consequently, benefits of using BIM are realisable within a short timeframe (Jurewicz, 2010).

No BIM-based life cycle considerations of buildings in NZ

The New Zealand Government has, in recent times, encouraged the building sector to utilise advanced information technology. As previously noted, this has focussed on the construction process productivity, design iteration and conflict reduction benefits. The literature contains many examples of these savings. However, there have been no significant attempts by anyone in New Zealand to apply BIM to post-construction phases such as in its application to Facility Management (FM) services. Based on the positive results of the two most recent overseas BIM-focused FM studies, i.e. Ballesty et al (2007) and Moon et al (2011), the New Zealand Government could expect that its FM practices could be streamlined to make it more cost-effective and efficient (Roberti & Buckett, 2012).

The focus on FM makes sense in the NZ context. By concentrating on the added value that BIM can provide to clients through a building's life span, the initial start up costs can be defrayed through the life of the building. This approach would appear to be the best way of creating the aforementioned 'compelling case' for BIM amongst the NZ industry's principal funders (clients, banks and venture capitalists). The internal logic seems clear. BIM may or may not improve the construction process on a case by case basis. But since each building, especially in a small economy such as NZ, is a one off entity it cannot be directly compared to an identical project procured, designed and delivered in the traditional way. The total process costs cannot be directly measured and compared like for like. However if a BIM delivered buildings are monitored over a period of time against traditionally delivered buildings, then it should be possible to establish the cost to run per square metre of real estate.

If the unit costs for FM of a building are demonstrably lower, then it should be possible to create the conditions for the employment of BIM at an early stage of new projects. Experience has shown that the best encouragement for the New Zealand building industry is for it to have access to successful value cases (Bunting, 2011). Further, such value cases need to result in a group of experienced practitioners wanting to share their knowledge. This is especially important for companies, and the building industry as a whole, during the current fiscal environment, where businesses are cautious on investments on new technologies. Indeed, without clear benefits (financial or strategic), BIM will be a costly but unviable experiment. Conversely, once the case is clear, compelling and based on a robust evidential data set, BIM becomes the standard benchmark of expectation and performance. This in turn creates a virtuous circle of positive reinforcement. Once BIM is standard, there is no requirement to make every project a test case of 'to BIM or not to BIM'. Also, for organisations that use BIM, the unique costs of using BIM on a project will be automatically absorbed by, and/or accounted into, the standard operating costs of the business.

Recommendations

The literature and the general sentiment in the construction industry around the world are very positive about the use of BIM. Literature abounds with lots of good reasons for BIM implementation. Usually the case study findings are accompanied by professionally photographed images of landmark buildings. However, from a New Zealand perspective, BIM implementation is a much larger and more complex 'hairy' problem to address. Hence, there is a pressing need to 'shave' the case for BIM to its essentials and thus provide the compelling evidence to make it work in a NZ context. From discussions above, it is apparent that there are a number of gaps that need to be filled, including:

1) **BIM-based Construction Management Research:** Although clients and procurement advisers are key contributors to the successful implementation of a BIM approach, there is currently a serious lack of research on the effects and benefits of BIM in procurement and contract management arenas. Despite the fact there have been initiatives overseas in addressing this deficiency, there is currently no such approach in NZ. It is therefore important that actions need to be taken swiftly to fill this knowledge gap. Specifically, Procurement decisions, Terms of Appointment for designers and Forms of Contract need to be considered from inception to enable a collaborative working environment.

2) **Streamlining of BIM:** There is an urgent need for industry and government bodies in NZ to take actions to promote the use of BIM in the construction and building industry. In particular, Standards NZ and big councils like Auckland and Christchurch City Councils work together to ratify the draft BIM standards with the key disciplines of architecture, structures and building services. Further, such organisations can liaise with the Government to encourage BIM as a model of future information management,

collaborative processes and potential for innovation. At present government is moving to a position in which all significant public procurement will mandate the use of BIM during design and development. How this is operationalised in the reality of the current NZ 'BIM-lite' environment remains a moot point. Historically the NZ government has seen numerous policy backtracks over the years on issues ranging from education through defence to indigenous rights. Current changes are aimed at reducing bureaucracy in the consenting process. It could take some years to fully institute BIM for government projects. In the meantime there is a pressing need for research into the 'best ways' of using BIM in the NZ context.

3) **BIM-based Facility Management Research:** Finally, there is currently no BIM-based Facility Management framework in NZ. Indeed FM as a field in NZ is comparatively weak compared to elsewhere in the world. FM is primarily taught at universities through property degree programmes. In numerous other countries FM is a recognised stand alone degree at both undergraduate and post graduate level. Construction and facility management of a building are two sides of the same coin. Therefore there is a need to develop a framework to address this issue, like one done at the design and construction phases. From the discussion earlier it can be seen that FM cost data and analysis would make the best possible case in which client demand 'pull' will affect industry practice.

To this end, there is an urgent need for research organisations in New Zealand to investigate the benefits that BIM can deliver to client organisations. In particular, the focus of such research programmes could be on the three recommendations mentioned above. However, given that BIM covers a wide range of areas in the construction sector (as seen in the literature review section), it is near impossible for one research organisation to carry out investigations alone to cover all six categories. Therefore, there needs to be a coordinated way forward in NZ. One such approach is a joint BIM research programme in New Zealand focusing on construction management aspect of buildings.

This joint programme could revolve around major research organisations in New Zealand integrating their activities such that the problems outlined in this paper can be broadly addressed. Also with an economy so small and academic research capability relatively limited, there is not sufficient resource available to 'double up' on research areas. There are significant opportunities at present to develop this data set. Several major research institutions are committing themselves to major infrastructure investment which should provide ideal research 'living laboratories' for BIM implementation and use. Building Research Association of New Zealand (BRANZ) recently built a new office complex that was rendered in BIM. Similarly both AUT University and the University of Auckland have huge multi-year, multi-building investments planned ($600m and $1bn respectively). Looking forward, there is an anticipation that various new governmental buildings will be available for adding to the data set for such an integrated programme of study.

For a short term research agenda, tracing of knowledge gaps or knowledge related risks is essential. Specifically, research questions are 'What don't we know about BIM and its application?' 'Are there associated unintended risks?' and 'Does BIM make buildings more sustainable?' Longer term, BIM-focused research questions should be revolving around FM of NZ building stock.

Indeed this is a good situation to be involved in right now because the test-bed for BIM is immediately available for the New Zealand construction industry. Furthermore, the three above-mentioned client organisations have a knowledge resource advantage. For example, the University of Auckland has one of New Zealand's top BIM experts as their in-house advisor. With so many research institutions involved, there is an immediately accessible and cost-effective pool of knowledge to utilise. This research programme is an ideal opportunity to monitor, guide and facilitate the early adopters of BIM in the country. In particular, as a knowledge transfer mechanism, all lessons learned could be integrated directly into educational programmes for students, as well as the building sector, through tertiary educators involved the consortium.

CONCLUSION

This paper has reviewed and analysed the current BIM uptake in the NZ construction industry. Despite it being useful and widely used in overseas construction markets, BIM's application in NZ remains limited, especially in "post-construction" phases like facilities management. In particular, the paper found that the three reasons why BIM has not been widely accepted and used in New Zealand are: the slow uptake by NZ construction companies; a lack of Kiwi-focused BIM initiatives (lead by the government and industry bodies); and a lack of BIM-based building life cycle considerations.

The paper then suggested that there is an urgent need for a joint research programme in NZ to develop a Kiwi-oriented knowledge base on BIM. Given the fact that major research organisations such as BRANZ, AUT and The University of Auckland currently have development plans in their pipelines, coupled with potential developments of Christchurch City, it is an ideal time to take a BIM-based research initiative in the country. In particular, the joint BIM research programme in New Zealand should focus on construction management process of projects, including procurement management, contract management, information management, as well as post-construction aspects such as facility management.

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