CURRENT AND ANTICIPATED FUTURE IMPACTS OF BIM ON COST MODELLING IN AUCKLAND

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ABSTRACT

5D Building Information Modelling (BIM) models contain data consisting of 3D objects which also include information relating to construction scheduling and cost aspects, and has the potential to be used by quantity surveyors (QSs) for such tasks as quantity take-offs, estimation and cost management (i.e. cost modelling), in a collaborative project environment with design team members such as architects and engineers. A 'snapshot' of 5D BIM use in Auckland is presented, based on structured interviews which gained the perceptions of 8 QSs, on both the current and likely future impacts of 5D BIM on cost modelling. Results suggest that in Auckland there is currently a low level of engagement with 5D BIM, and thus it has a low impact, although a small number of QSs indicate they are already using 5D BIM in a limited manner for some aspects of cost modelling. Most QSs interviewed thought that 5D BIM would have an extremely significant impact in the future, as the process becomes more prevalent.

Keywords: building information modelling, cost modelling, design stage estimating, quantity surveying

INTRODUCTION

In recent years, productivity in the New Zealand (NZ) construction industry has decreased, and this is attributed to a lack of innovation in construction processes, compared to other industries (Department of Building and Housing, 2009).The use of building information modelling (BIM) provides the opportunity for innovation in the process of construction project delivery, and in a recent NZ survey of non-residential builders, "technologies to share information" was considered to be an important factor affecting productivity (BRANZ, 2013).

BIM has been in use internationally for several years and its use continues to grow. New Zealand's only national BIM survey recently found an increase in overall BIM awareness in the construction industry; 60% of respondents had some understanding of BIM, 20% had a reasonable appreciation of its potential, and a further 10% had a clear appreciation of its benefits (Masterspec, 2012).

BIM extends its use to incorporate a 4^{th} dimension (4D), 'time' and a 5th dimension (5D), 'cost,' which specifically concerns the quantification,

modification and extraction of data contained within the model in order to become the primary source of information for cost modelling [cost models are technical aids which enable management decisions to be made in the context of building design (Skitmore & Marston, 1999)]. This research focuses on the cost dimension of BIM (5D), which aims to present a "snapshot" of Auckland quantity surveyors' (QS) perceptions on the current and likely future impacts of 5D BIM on cost modelling.

BIM & 5D FOR COST MODELLING

A building information model (BIM) is a "data-rich, object-oriented, intelligent and parametric digital representation" (American General Contractors, 2006, p.3). It is these "data-rich" objects that support the function of cost modelling; 5D BIM contains objects and assemblies in the BIM model that have a cost dimension added to them, either by incorporating cost data within the BIM model objects themselves, or which can be "live linked" to estimating software tools, which is current practice in New Zealand (Boon & Prigg, 2012). [NB: Exactal's CostX, and Vico Software's Vico Office are examples of commercially available 5D software commonly used in New Zealand (Exactal (n.d.); Vico Software (n.d.)]. Parametric modelling then, facilitates the creation of a relationship between elements, and includes the specification and properties of individual elements and objects, [potentially] enabling the extraction of comprehensive and accurate information from the model which can be directly used for costing (Eastman et al., 2011). It is thought that a transition period is occurring at present from the more traditional methods of quantity surveying to using BIM for cost modelling. However, progress is slow, and the use of 5D is limited; even in the UK, in 2011 only 10% of QS practices were using BIM, and only 5% had used 5D BIM to extract quantities (BCIS, 2011).

The use of BIM in New Zealand private quantity surveying (PQS) practices, whilst not as advanced as internationally, is developing. However, a single BIM model that contains all design documentation is not apparent within the New Zealand market; instead, projects often utilise up to three different (and separate) models, which can encompass architectural, structural and services design documentation (Boon & Prigg, 2012). Most of New Zealand's construction industry is still at Stage 1B ('Intelligent 3D') of the BIM implementation scale (Figure 1). There is *some* anecdotal evidence that a *few* NZ construction projects are operating at Stage 2A: 'One-way Collaboration', where the (single) BIM model can be shared with other project participants for visualisation, coordination, communication, assessment, analysis, simulation or discipline design. Feedback to the original BIM model author for design and coordination is in traditional formats and the original model is updated in digital isolation from other discipline models (Australian Institute of Architects, 2009).

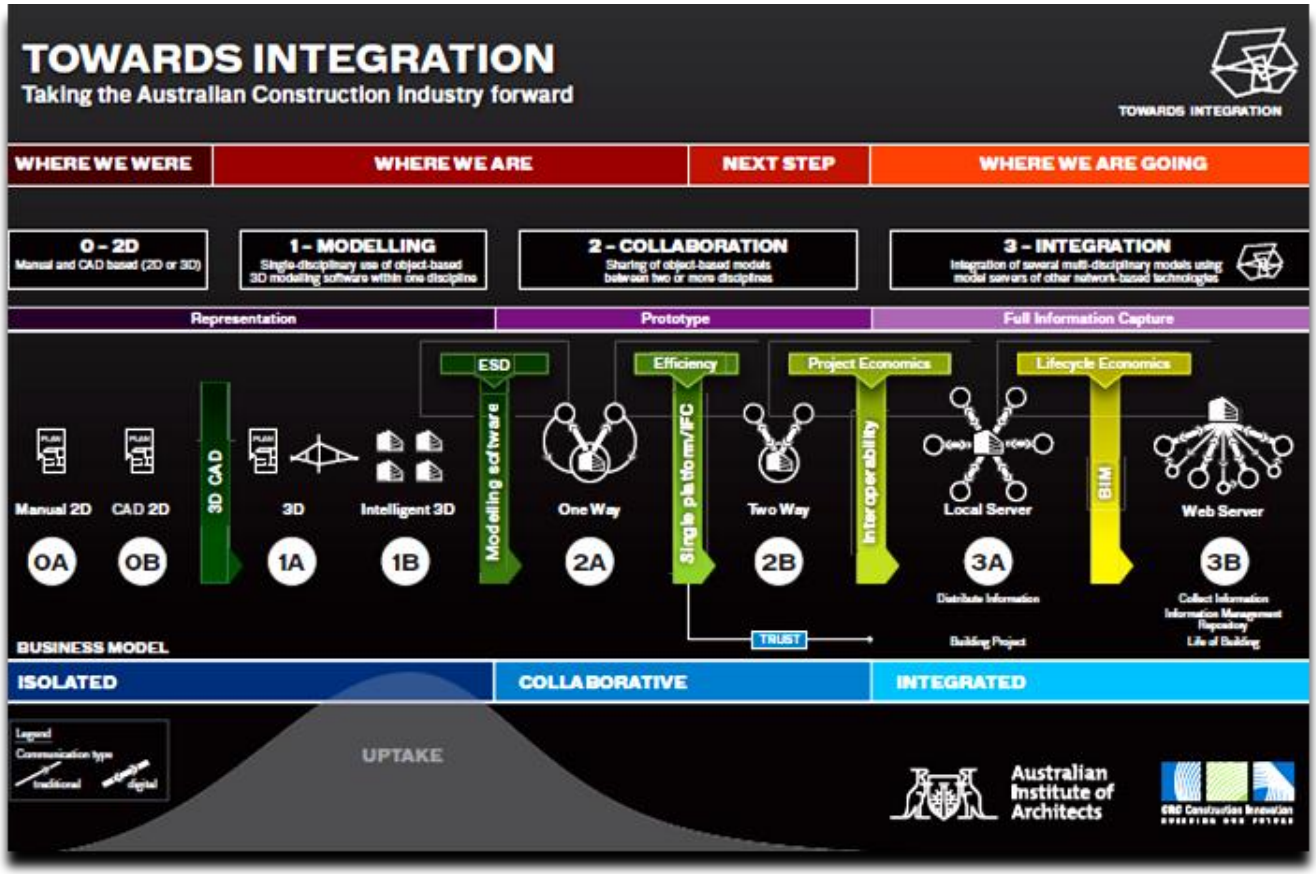

Figure 1 *Towards Integration* (Australian Institute of Architects, 2009)

Overseas studies have considered, for example, the benefits and barriers of BIM, in which estimators have been included (e.g. Sattineni & Bradford, 2011). However little research has specifically investigated the perceived impacts of 5D BIM, and so this research aims to provide a "snapshot" of Auckland quantity surveyors' perceptions on the current and future impacts of 5D BIM on cost modelling.

METHODS

A cross-sectional survey approach was adopted, conducted over a small time frame, which was considered appropriate, as technology tends to change quickly. The sample population were quantity surveyors, whether in private practice, or working for a contractor or sub-contractor. Purposive, non-probabilistic sampling ensured that only those people that had some BIM experience were selected. All responses were kept confidential, and participants' anonymity was ensured. Ethics approval was sought and obtained from Unitec's Ethics Committee.

Face to face interviews gave participants the opportunity to have the wording of questions clarified, and the interviewer the ability to ensure that the questions were interpreted as intended. In order to minimise the potential for introduction of interviewer bias, the interview structure and questionnaire were piloted beforehand. The interviews were recorded which enabled post-hoc analysis of qualitative responses, in order to further reduce bias. Though a structured interview format was used, it

also allowed for open ended, as well as closed questions. Demographic questions covered areas such as the number of employees in the participant's company, their role in the company, and the participant's experience with 5-D BIM. The format allowed the respondent to elaborate when needed, though also answer questions that were more targeted and closed, by using a semantic rating scale to assess the respondent's attitude towards issues. The points on the scale were attributed a number which could then be used for analysis, e.g. 1 to 5, and the ends of the scale were given opposite levels of agreement e.g. strongly disagree and strongly agree. Responses to the subjective open ended questions, were analysed by identifying the themes from the participant's responses and trends were identified. The closed questions allowed the data to be translated from the raw data onto spreadsheets and tabulated.

RESULTS & DISCUSSION

The demographic data collected from the eight participants is shown below in Table 1.

Table 1 Participants' Descriptive Statistics (n=8)

Participant	Job/Position	Years Experience	Number of BIM Projects	Number of 5D Projects
A	PQS*	35	0	0
B	Cntr QS** (Director)	15	1-2	0
C	Cntr QS	5	10	1-2
D	Cntr QS (Director)	30+	1-2	0
E	PQS (Director)	25	1-2	0
F	PQS	3	0	0
G	Cntr QS (Director)	18	3-4	1-2
H	PQS (Director)	24	1-2	0

*PQS: private practice QS; **Cntr QS: contractor's QS

Four participants were from private practice, and 4 from contracting firms, and had a variety of quantity surveying experience and seniority, as well as experience with projects using BIM models, wherever possible. Participants' level of agreement with statements relating to their perceptions regarding current and future impacts of 5D BIM on cost modelling in New Zealand are shown below in Table 2.

Cost model development

Only 2 out of 8 participants perceived an increase in the use of BIM to develop a cost model over the past 3 years, echoing Boon and Prigg (2012) who suggest that 5D BIM in New Zealand is used in a far more limited way than overseas. One participant said: *"Currently…we only use the BIM models to 3% of its capabilities"*. This suggests a large degree of under-utilization of 5D, and all 8 participants agreed that there would be increasing use of 5D in the future.

Table 2 Current & Future Impacts of BIM on Cost Modelling (n=8)

Strongly Disagree (1) to Strongly Agree (5)

Impact	Current					Future				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Increased use of BIM to develop a cost model	1	2	3	2					3	5
Increased use of 5-D in conjunction with traditional quantity surveying for takeoffs and estimating	2	2	2	2					4	4
Increased ability to prevent inaccuracies in measurement i.e. under and over-measures	2	1	3	2				1	4	3
Reduced time needed for quantification	1	2	3	2					3	5
More effective use of cost data for pricing e.g. use of an integrated cost database	1	2	5				1	3	3	2
Increased use of BIM during design stage estimating e.g. cost planning**	1	1	4	2				2	2	4
Increased use of BIM during tender/bid stage e.g. production and/or pricing of SOQ*	4		2	2				2	3	3
Increased ability to track changes in costs in real time due to changes in project scope i.e. a 5D model is able to be compared to alternative 5D models	2	1	4	1			2		3	3
Minimization of manual take-offs	2	2	3	1				1	3	4
Improved efficiency when pricing cost plans**	1	3	1	3			1		2	5
Improved efficiency when pricing SOQs*	1	4	1	2			2		2	4

*SOQ: Schedules (Bills) Of Quantities; ** cost planning: design stage estimating

5D BIM & traditional quantity surveying

Participants had widely differing views on the current level of 5D use in conjunction with traditional take-off and estimating activities; most participants were pressing on with traditional QS practice, but a small number were engaging with 5D. A participant stated *"If something needs to be taken-off or estimated, I'd definitely use BIM for it if it's available. You usually just have to ask for the BIM model and they'll give it to you."* However, all participants agreed that in the future, there would be increasing use of 5D in conjunction with traditional QS practices. Timing of the implementation of 5D BIM was seen as a critical factor; one participant stated *"do you make your run when everyone else out there have got probably a tenth of the designs that you get in some sort of BIM model or do you wait until perhaps 50% are being produced in BIM and then upskill and change your methodology."*

Measurement accuracy & efficiency

Participants' views on whether or not 5D BIM currently has much impact on preventing measurement inaccuracies, and on speeding up the quantification process were divided; most companies are still relying more

on traditional 2D technology, e.g. paper-based or .pdf plans. A participant noted *"a lot of traditional bulk checking still needs to be done."* However, there was optimism that 5D BIM will improve measurement accuracy and speed of quantification in the future. *"You are going to get to a point where you're going to realize that with BIM you're actually reducing the calc. errors and measurement errors, that it is a lot more beneficial."* Another participant stated *"An external wall that might have taken a good couple of hours to measure could be measured in about 3 mouse clicks."* This sentiment is echoed in the literature: Bylund and Magnusson (2011) suggest that through BIM it is possible to gain accuracy and speed up the process of take-offs, and Shen and Issa (2010) found that gains in speed and accuracy were achievable when using 3D models when compared to traditional 2D.

Cost planning & use of cost data

Most participants did not agree that currently 5D is increasingly being used for cost planning, with the effective use of cost data for pricing (e.g. by using an integrated cost database). However, there was very little disagreement with the notion that in the future, 5D will increasingly be used for cost planning, with integrated cost databases allowing more effective estimating at the design stage, and will lead to a reduction in cost and an increase in value to the client, which will be possible through enabling QSs to *"create new revisions"* and the ability to produce *"an early cost analysis right up front*". Indeed, the chief advantage of 5D BIM is that it "permits the re-estimation of an evolving design as many times as is required" (Building Economist, 2013, p.3).

Schedules (Bills) Of Quantities (SOQs)

Few participants agreed that there is currently an increased use of 5D BIM for the production and pricing of Schedules (Bills) of Quantities (SOQs) during tender/bid stage. This indicates a reliance on the more traditional methods of quantity surveying practice at bid stage. Given the competitive nature of tenders/bids in the construction industry, the need for quality data is important, and some participants thought that currently the data in BIM models lacks the accuracy and quality needed to be used in this situation. Standardisation issues, such as when descriptions for 3D objects and the same objects in 5D software don't match, may be one of the reasons for QSs not using BIM for the production and/or pricing of a SOQ (Boon, 2009). Six out of 8 participants agreed on the future increased use of 5D BIM for production and pricing of SOQs during tender/bid stage, with improved efficiencies over traditional methods.

Tracking design changes

Three of the 8 participants did not perceive that currently there is an increased ability to track changes in costs in real time due to changes in project scope, i.e. a 5D model being able to be compared to alternative 5D models at present. However, 6 out of 8 felt that this would change in the future. Popov et al. (2008) suggest that with 5D BIM, design changes

are easily accommodated, allowing investigation of design alternatives and selection of the best option, which will increase the impact of 5D BIM on cost modelling.

Manual take offs

Only 1 of 8 participants agreed there is currently a minimization of manual take-offs due to 5D BIM. However, 7 out of 8 participants agreed that this would change in the future. There is already an impact in this area from 5D, as one participant commented *"I haven't used a scale rule in about 2 years now."*

Responses to open ended questions

Participants' responses to open ended questions on impacts of BIM on cost modeling were collated, and a summary is presented in Table 3 below.

Table 3 Summary of Open Ended Question Themes

Visualization of projects is increased.
Early identification of risks through clash detection.
Lack of software compatibility restricts its use.
Cultural resistance in companies hinders its effectiveness.
Lack of integration in the model decreases the reliability and effectiveness of 5D.
Lack of an electronic standard for coding BIM software to standard methods of measurement (SMMs) limits the potential of BIM for cost modelling.
An increased use of BIM during tender/bid stage at present e.g. production and/or pricing of SOQs.
The likely increased use of BIM in future to develop a cost model.
Increased time saving by using 5D
Increased accuracy by using 5D
Lack of quality assurance of the data in BIM models.
The fragmented nature of the construction industry
BIM's current capability
2D drawings are needed to show some details as BIM doesn't show the required level of detail.
BIM models don't show some items correctly.

A common theme discussed by the participants was the need for BIM models to be correct, complete, and for model objects to contain all the data needed for 5D cost modelling. At present, this is often not the case, and time is needed to pick up what is not shown in the BIM models, by reviewing 2D drawings that show the missing detail. As such, 5D BIM is not used much for cost modelling, as there isn't the gain in efficiencies required to make it a viable option to businesses. Through model mapping, quantities can be measured; however it requires time to find the required information in the BIM model in order to measure the items. Skills need to be learned by those using 2D quantity surveying processes,

to be able to successfully obtain the data in the form required (Hannon, 2007). One participant commented *"it's all about visualization… traditional drawings have a lot of detail in them and you have to build it up in your head. If only you could take all the detail on those drawings and put it into a model."*

Boon (2009) mentioned 2 companies that were working cooperatively, so that their software was inter-operable, where 3D CAD software is able to work seamlessly with 5D software; perhaps other companies may follow a similar pattern and work together to make 5D work successfully for them and in doing so gain a competitive edge. If the different disciplines - architectural, structural, mechanical, electrical, quantity surveying, etc.- could work collaboratively on BIM models, projects might be more likely to be more successful (Roberts, 2012). Referring back to Figure 1, this is akin to Level 2B: 'Two-way Collaboration', where common BIM model file data can be shared by two or more project participants in an iterative and collaborative process, greatly enhancing feedback and producing closer integration of disciplines (Australian Institute of Architects, 2009).

One participant described how people are working to make a *"library of standard items"* and commented that it would be good if it was used throughout the world. The New Zealand Coordinated Building Information (CBI) classification and coding system established by the Association of Coordinated Building Information in New Zealand (ACBINZ) could form the framework for such a BIM library/database.

Another issue raised was that as the older, more experienced QSs in industry may be new to the 5D environment, a problem will arise; who will oversee and carry out the QA process on more junior, younger staff? *"How it's audited, who its' audited by, does it need to be audited by someone in a similar position to him?".* Moreover, *"You still need to be able to measure correctly…know the theories behind it"* and *"the method of measurement still needs to be done".* To address this, in future, a balance between those with extensive QS expertise, and those with BIM model experience/skill will need to be found, to develop new QA processes, and maintain the integrity of measurement while using 5D BIM.

CONCLUSIONS

The research has identified the perceptions of a sample of Auckland quantity surveyors on the impact of BIM on cost modelling, both currently and in the future. The findings suggest that current use of 5D BIM for cost modelling is somewhat limited, and is restricted to certain specific aspects of cost modelling such as quantity take-offs for cost planning purposes. The bulk of the cost modelling function is still being carried out using traditional QS methods, although QSs perceive that 5D BIM will take precedence for cost modelling over traditional QS methods in the future.

Participants commented on the barriers to 5D BIM implementation, such as lack of integrated BIM models, with objects containing full and complete data required to fulfil cost modelling tasks efficiently. Some participants noted that in the future, such barriers are likely to be overcome by increasing cross-disciplinary collaboration on BIM modelling, allowing 5D BIM use to become more prominent.

Although (due to the small sample size) these findings are not generalizable to the New Zealand quantity surveying population as a whole, they do provide a 'snapshot' of current opinion on the impact of BIM on cost modelling. The accelerating implementation of BIM means that these perceptions are likely to change in the future, and this research provides a benchmark against which to gauge changes in the use of 5D BIM for cost modelling, which could be the subject of further research.

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