FACTORS AFFECTING THE UPTAKE OF BIM IN THE AUCKLAND ARCHITECTURE, ENGINEERING AND CONSTRUCTION (AEC) INDUSTRY

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ABSTRACT

Building Information Modeling (BIM) is seen as the next paradigm shift in the building design and construction industry since the move from traditional drafting to 2D computer aided design systems. Although BIM has been available for a number of years worldwide, its adoption and use in the New Zealand, and especially Auckland Architecture, Engineering and Construction (AEC) industry has been relatively limited.

The aim of this research is to explore the factors affecting the uptake of BIM in the Auckland market by incorporating the views of various architecture, engineering and construction firms. This study is based on a qualitative research methodology. A number of semi-structured interviews, using a questionnaire guide, were conducted with industry professionals from the architecture, structural engineering, services engineering, and construction contractor industry sectors to gain an insight into their current use of BIM and identify what benefits and barriers they encountered in its use and implementation.

The findings of this research showed that most industry sectors are currently using BIM as a three dimensional tool for coordinating the various design disciplines, as well as for 3D clash detection and 2D documentation production. Other reasons for BIM use included producing 3D and 4D visualizations and virtual walkthroughs to help non-technical people understand the design intent. Although the literature describes training and cost of implementation as major factors affecting the uptake of BIM, most of the research participants downplayed these issues, explaining that adopting BIM was a commercial decision made to stay ahead of their competitors, and that the extra training involved actually improved the skill base of their organizations. This study concludes that to progress with the use of BIM, a truly integrated and collaborative approach must be adopted in order to achieve gains in coordination, productivity, cost management, and overall project outcomes.

Keywords: BIM, AEC industry, 3D modeling, 4D visualization, Survey

1. INTRODUCTION

Building Information Modeling or BIM, as it is widely known, is described by many as the future of the design and construction industry and the way in which buildings are both designed and built. While traditionally, buildings have been drawn on and built from two-dimensional (2D) plans, sections and elevations, they can now be viewed in a detailed n-dimensional model which not only shows the three-dimensional (3D) geometry of the building, but can also incorporate construction programmes, sequencing (4D) and cost information (5D), through to sustainable design information, specifications, and health and safety information. The main focus of this paper is on the application of these various BIM aspects to the New Zealand, and specifically Auckland Architecture, Engineering, and Construction (AEC) industry, as the extent of BIM use in the country and the many perceived benefits and barriers are not yet entirely clear.

The literature review undertaken in this study attempts to establish what the current uses of BIM are, to what extent it is used, and also what benefits have been found through its use, as well as the barriers to its adoption. Various literature sources provide evidence that significant improvements can be made in time, cost, and quality factors through the use of BIM, however there are also a number of barriers to overcome before BIM can be implemented on a larger scale. The aim of this research is to explore the factors affecting the uptake of BIM in the Auckland Architecture, Engineering and Construction (AEC) market through conducting semi-structured interviews with various architecture, engineering, and construction firms. This multi-faceted qualitative research approach was favoured as it could provide rich data and alternative viewpoints of industry professionals engaged at various projects' design and construction stages. In turn, the results of the research could be used to find ways to achieve higher rates of BIM adoption in the Auckland market, thereby improving project results for all parties involved – clients, contractors, designers, and end users.

2. MULTI-FACETED AEC RESEARCH APPROACH

The multi-faceted AEC research approach was chosen as the most suitable for this study aiming at developing an in-depth understanding of the current state of Building Information Modeling (BIM) use in the Auckland AEC industry. Understanding how BIM is perceived by various industry professionals determined the choice of research method. For the purposes of this study, the AEC industry was split into four distinct industry sectors or groups: consultant architecture firms, consultant engineering firms, consultant services engineers, and construction main contractors. Each of these groups had its own perception and understanding of BIM, and therefore perceived different benefits and barriers to its adoption. This study compared the views of each group with one another, as well as with the factors described in the literature to produce a snapshot of the current state of BIM use in Auckland.

Suermann (2009 p.98) found that when his research began in 2006, there was limited empirical data available regarding the use of BIM, so a qualitative study was first undertaken to determine industry's perception of BIM. The same finding can be applied to the local environment, in that there is very limited existing literature or research in regards to BIM use in New Zealand. This study attempted primarily to create a snapshot of the current state of BIM use in the Auckland AEC industry, and determine the key factors both for and against the use of BIM. The main aim was to extend the understanding of the reasons for the slow uptake of BIM, specific to the Auckland AEC industry. The limited use of BIM in New Zealand to date means there are too few project examples to study, to be able to develop any meaningful quantitative data on BIM's effects on project key performance indicators. These factors have led this study towards a qualitative approach, where interview data was analyzed to discover what the key ideas and patterns were behind BIM use in the Auckland AEC industry.

2.1 Participant selection and sampling

There is a vast amount of literature available on the topic of BIM. The issue, however, is that the majority of published research is based on overseas findings, which do not necessarily correlate to the New Zealand AEC industry. The Auckland AEC industry is made up of numerous types of organizations, from independent architects, through to nation-wide construction contractors. These can be further sub-categorized into small, medium, and large enterprises, ranging from self-employed builders, through to companies with 500 plus employees. Due to this large variation of samples within the AEC population, probability-based sampling would not have been appropriate, as it might possibly lead to unsuitable participants being selected. This might include independent architects or builders who have had little or no exposure to BIM technology, and would provide little beneficial insight into the research issues. For the reasons described above participant selection was based on non-probability sampling, and more specifically, purposive (or judgmental) sampling, where the participants were 'hand-picked' (Denscombe 2007 p.17) because of attributes already known about them. In this case, those attributes were based around the participant organization's previous, current, or future use of BIM, the organizations size, and the industry sector the organization operated in. The participants were selected from one of each of the following types of organizations: Consulting Architecture Firm, Consulting Engineering Firm, Consulting Services Engineers, and Construction Main Contractor.

The sample size for this research was limited to three interviewees from each organization type identified above. The interviews were held with employees involved in the production of BIM documentation, as these were the people who would have the most in-depth knowledge of BIM from using it on a day to day basis. Another contributing factor to the small sample size was the availability of appropriately qualified and knowledgeable, in regards to BIM, professionals in the Auckland AEC industry. To ensure a degree of reliability, the methodology of this research was carefully detailed to ensure similar findings could be achieved by other researchers if this study was to be repeated. Creswell (2007 p.206) describes validity in qualitative research as a measure of accuracy of the findings. To ensure all findings can be deemed accurate, all interviews were recorded by means of a digital voice recorder, which were then transcribed. A copy of the transcription of the interview was then given to the interviewee to confirm that what was said in the interview was concurrent with what was recorded in writing. Validity was also achieved through triangulation of the initial interview findings with the findings of other research in the literature.

2.2 Data collection instruments

2.2.1 Interviews

Semi-structured interviews were conducted with all selected research participants at a convenient time and date to both the participants and researcher. They were held in the business offices of the selected participants as this placed the participants in a setting in which they felt comfortable to respond to interview questions openly and honestly. The interviews followed a general interview guide as discussed by Turner (2010 p.755), in that the interviews were more structured than an informal discussion, but were flexible enough to allow questions to be modified or rephrased depending on the situation to get better responses from participants. This approach "[ensures] that the same general areas of information are collected from each interviewee" (McNamara 2009). The general interview guide contained a number of base questions as outlined below, however in the cases when further information was required from the participant, these questions were elaborated on to gain better responses.

2.2.2 Interview question guides

The interview questions were split into three different stages as detailed below.
Stage one questions were used to establish demographic information about the research participants and their organizations, such as business size, typical project type, size and value, and staff numbers. Most of the questions in stage one were closed and therefore resulted in short, simple responses. These are necessary to determine the participant's point of view for later responses.
Stage One Questions

- What type of project is your organization predominantly involved with?
- What type of work do you (and the organization) undertake on these projects?
- What is the typical size (and value) of these projects?
- How many people are employed by your organization?

In stage two the focus of questions moved to discuss how BIM was used by the organization and the benefits found as perceived by the participant. These questions also became more open-ended allowing the participant to elaborate more on their responses.
Stage Two Questions

- "To what extent is building information modeling used by your organization? 3D modeling, or full 4D/5D time and cost data also?"
- What type of projects (type/size/value) has your organization previously used, or is currently using BIM on?
- "What benefits has your organization found in the use of building information modeling?"
- "Do you think the use of BIM has led to improvements in project time, cost, or quality factors?"

Stage three investigated what the barriers were to the uptake of BIM and how these were overcome by the participant organization.
Stage Three Questions

- "What barriers were found in adopting BIM?"
- "Do the benefits of BIM use outweigh the barriers?"

Throughout these interview questions the participants were invited to go into more depth with their responses and elaborate further based on their experiences with BIM.

3. DATA INTERPRETATION AND ANALYSIS

3.1 Data collection and management

Data collection commenced in a series of semi-structured interviews with architecture, engineering, and construction industry professionals. These included design managers, senior structural engineers, project architects, and services engineering 3D modeling managers based in practices in the Auckland area. These interviews varied from 45 to 60 minutes in length, and were all held at the participants business offices. All interviews were voice recorded with the permission of the participants, and were transcribed immediately following the interviews. An excerpt from one of the interview transcripts can be seen in Figure 1 below.

difficult one to quantify because you do the BIM modelling, or you do any sort of coordination work in the office and, hopefully it solves all those problems and you don't have any problems on site, but you don't see any value in it at that point because, but if you hadn't done that process, then [laughs] you know, there could be a twenty grand delay with cranes hanging around steelwork that doesn't fit, so it's kind of a catch twenty-two where you're doing it and the project runs smoothly and it's like well, if we didn't do that would the project run so smoothly, and no one's prepared to step back and not coordinate it and not do that.

CMC: So as you're saying, it's harder to actually quantify what that benefit is.

MG: Yeah, there's a definite benefit as I said before from us doing 3D little images and sketches and developing

Figure 1: Interview transcript excerpt

The interview recordings were generally transcribed within 48 hours of undertaking the interview, to retain a fresh memory of what was said, and any other non-verbal cues. To maintain a degree of validity, the completed transcripts were sent to the interview participants via email, for them to confirm that what was recorded was a true representation of what was said in the interviews. After checking the transcripts, the participants signed, dated, and returned them for record keeping. The raw data collected from the interview process, in the form of interview transcripts, equated to approximately 18,000 words over 30 pages. To make sense of all this raw text, each of the interview transcripts was broken down into sections, split by question as based on the interview question guide. A table was generated with each row representing the different questions asked and each of four columns representing the interview participant/industry sectors. The responses of the participants in the transcripts were distilled down to the basic ideas, making the tabulated results much more concise. The tabular presentation of the raw data helped in identifying basic patterns and trends.

3.2 Data analysis and coding

Data analysis was undertaken using a thematic analysis process, whereby the raw data in the form of interview transcripts was read, and re-read, until the content was familiar and could be recalled easily.
A simple code structure was developed based upon the initial literature review ideas and themes. Each of the key themes from the literature, including coordination, buildability, cost, and training was given a unique code number from 1 through to 10. The transcripts were then re-read, and wherever these ideas appeared, the related code number was written beside to make that area of text easily identifiable. The codes used were as follows: (1) Coordination, (2) Clash Detection, (3) Buildability, (4) Visualization (3D), (5) Visualization (4D), (6) Cost Estimating (5D), (7) Cost, (8) Training, (9) Design Process, and (10) Interoperability/Compatibility.

Table 1: Summarized table of finding

Question	Main Contractor (A)	Structural Engineering (B)	Architecture (C)	Services Engineering (D)
2.1. For what reasons does your organization use BIM?	Design and build all risk taken by contractor, better coordination to reduce risk to them.	Better coordination with other consultants	Coordination with other designers Faster production of documents	Explain designs efficiently Reduce mistakes in documentation Efficiently update all documents Better coordination with other consultants
2.2. Are other software packages such as AutoCAD used alongside BIM software?	Revit 2011 Revit MEP Evaluation Version ArchiCAD 14 AutoCAD	Revit Structural AutoCAD EMAPS Various structural analysis packages – Microstran etc	Revit Architecture ArchiCAD Artlantis Photoshop	Revit MEP AutoCAD MEP CUBE (Firm specific database) integrates with Revit Services analysis packages
2.3. To what extent is building information modeling used by your organization? 3D modeling, or full 4D/5D time and cost data also?	3D geometry, structural visualization, purely for coordination of Arch/Struct Some 4D visualization by 3rd party	3D geometry for producing construction documentation	Mainly 3D geometry for document production Some use of 4D and 5D currently in development	3D geometry + object specific data, i.e. mechanical plant data, costs, flow rates etc
2.4. Is additional third-party software such as Navisworks or Vico used to produce the 4D/5D data?	No other software – clash detection done in-house within one BIM model. 3rd party consultant sometimes used to produce 4D virtualizations	Mostly done within Revit as other consultants also using Revit. Revit models being shared between consultants	Mainly done within Revit Vico Office package used for 4D/5D information	Navisworks, used to combine services BIM model with architectural model, structural model, to combine all information
2.5. What type of projects (type/size/value) has your organization previously, and/or currently using BIM on?	Any design and build projects where cost of BIM use can be absorbed into design fee	All new projects using Revit, currently 3rd party doing additional BIM (4D/5D) on $250mil Hospital project	All projects in previous years done in ArchiCAD. New projects being done 50/50 Revit/ArchiCAD	Not currently using a lot of BIM in New Zealand. Used on around 50% of projects

4. FINDINGS AND DISCUSSION

4.1 Current use of BIM in the Auckland AEC industry

All surveyed participants were from medium to large organizations, consisting of approximately 30 or more employees, with between two to ten personnel directly involved in the use of BIM modeling and other drafting tools. The current use of BIM in the Auckland AEC industry appears to be limited to producing 3D geometry as a method of creating 2D construction documentation, as well as a basic 3D coordination, clash detection, and visualization tool. Only one main contractor participant had gone to the extent of 4D visualizations that incorporated time and programs data, although it was done on their behalf by an external BIM modeling consultancy. All architectural participants had also used BIM as a method of producing photorealistic 3D visualizations of proposed buildings as a way of showing their clients what the completed buildings would look like. This matches the findings of Azhar et al. in that "most companies use BIM for 3D/4D clash detections and for planning and visualization…" (2008 p.4).

Only one architecture participant had gone to the extent of incorporating 5D, or cost data, into their models. From the other design consultant participants' point of view, it was the construction contractor's role on a project to establish construction programs and costing data, so it was not in their interests to incorporate such data into their BIM models. On the other hand, the main contractor participant stated they were "nervous" about embedding cost data into the model, and preferred to "leave it up to our quantity surveyors" to estimate the construction costs using traditional schedules and take-off methods. This is obviously a cultural barrier to BIM, as although the main contractor participant has been innovative in adopting BIM, they are still hesitant in moving away from their traditional estimating methods, to a full 5D BIM approach.

4.2 Benefits of BIM

4.2.1 Improved coordination

All of the participants highlighted improved coordination as the most common benefit of using BIM technology. This applies to the coordination of various structural elements, both between each other, and also with building services. In one situation, the main contractor participant described receiving documentation for a traditional tendered project. His comment:"When we got the documentation from the consultants it was a complete mess", described the complete lack of coordination apparent in the original documents. Due to a tight program, the main contractor participant decided to take on some of the design risk to completely re-model the project in BIM. Through the use of BIM they were able to completely coordinate "the precast and steel and everything," and construct everything on site "like a piece of Meccano.". This was all done despite coming to site four weeks late due to the re-modeling process, yet still completing the project on time and within budget. This highlights the benefit of the BIM coordination process, in being able to significantly reduce construction programs by coordinating all the different structural elements and services.

The main contractor participant also explained how they used BIM as a tool for coordinating their specialist subcontractor's work. For example, they would sometimes produce shop drawings themselves for items such as complicated precast panels where they also had the experience and knowledge of any other items interfacing with those panels such as glass balustrades.

The structural engineering participant also agreed that the use of BIM had improved coordination, particularly where all the designers involved with a project were using the same software, in this case Revit, but believed the coordination of the complete building including services was more the responsibility of the builder. This finding was matched by the architecture participant who found that coordination between the design disciplines worked much better when compatible software was used.

4.2.2 3D and 4D visualisation

Most of the participants used BIM as a tool for producing 3D visualizations of the buildings they were involved with. This varied from the services engineering participant using it to model complex pipe and duct runs around structural elements, to the architect participant modeling an entire building to give their client a picture of the finished product. The architecture participant also described the use of the Vico Office software package which allowed them to incorporate the construction sequence into the 3D model and show what the project construction might look like at any given time. Some of the participants described using 3D BIM modeling to model complex reinforcing details or other complex junctions to "coordinate things out on site" or "show them how everything might fit together."

4.2.3 Faster, more accurate construction documents

Most of the research participants felt that BIM allowed for producing documents quicker and more accurately than previously, as per the findings of Woo (2007 p.3). The services engineering participant explained that the use of BIM tools, Revit in particular, had reduced the number of mistakes in their construction-issue documents. He went on to explain that, where previously with CAD, "a simple change to one piece of your design, might have meant changing ten to twenty drawings" manually, the change was now being made once to the BIM model, and automatically propagated through all drawings and documents. The structural engineering participant agreed that changes were being made to the model once, but did not believe the reduction in time was so substantial. He suggested the design team and drafting personnel still had to manually check through every plan, elevation, and section to check that labels and other notes were still in the correct positions and that no other mistakes were present. The architecture participant also noted that the speed in which documentation could potentially be issued was a key benefit of BIM use.

4.3 Barriers against BIM

4.3.1 Training

The training and upskilling of staff was only seen as a minor factor in impeding the adoption of BIM by all participants. Methods of overcoming this barrier ranged from having a company in-house BIM training facility with 12 dedicated computers solely for staff training purposes, to hiring staff to the BIM modeling department who already had the skills, expertise, and competence to start BIM modeling immediately. Some of the participants believed that many coming into the industry now, such as university architectural and drafting graduates, were already competent in many of the BIM modeling packages.

These results are in stark contrast to the findings of Gilligan and Kunz, who found that the "majority [of organizations] now see training and availability of staff as most limiting" (2007 p.13). This contrast, however, may be attributable to improvements both in the use of the BIM technology, as commented on by the structural engineering participant, or in the level of industry personnel training, in the three years since their report was written.

The architecture participant explained that the "time to train people up, and the cost for that" was an initial issue in the adoption of BIM within their office, however believed the continual training of their staff, which was done "in house" and "on the job," was actually a benefit to the company. Their company's plan was to train all of their staff in both ArchiCAD, which was already in use, as well as Revit, which they believed was more commonly in use in the AEC industry.

Another issue of staff training that was raised by most participants was that of the education of other staff within their organizations, not those directly involved with BIM, but others who used the services of the BIM users as part of their day to day business, such as the site and project managers, or project engineers. These indirect users of BIM were required to be trained in the basics of BIM so that they would not expect too much from the BIM users, in terms of what was possible and how long it would take. This was dealt with by the services engineering participant who explained that all of their organization's project engineers were sent to the training centre described above for basic BIM training.

4.3.2 Cost

Cost did not rank highly as a barrier to BIM to any of the interview participants, in terms of software cost, computer hardware cost, or training cost, as most participants saw the use of BIM as a natural progression of the business. The structural engineering participant described not using BIM as "falling off the back of the bus," as it would see them fall behind the advancements of other engineering consultancies, and potentially lose future business because of it. The architecture participant also agreed it was a business decision to go forward using BIM, therefore the cost did not impact greatly on them adopting BIM.

The main contractor participant explained that they had always had license fees for CAD software, and always had the computer hardware associated with it, so there was no "spectacular" cost difference in license fees between CAD and BIM and the minor hardware upgrades required to run it. They saw BIM as "a tool of the job," something that was needed, so therefore the cost of moving to a BIM approach was insignificant for them. Much of the literature that described the cost of implementing as an issue (Holness 2006 p.42) is now a number of years old, therefore the cost of both BIM software and the related hardware may have reduced significantly since then, lessening the impact that cost has on the adoption of BIM.

4.3.3 Lack of empirical data supporting BIM adoption

Yan and Demian found that there was a "lack of case study evidence of the financial benefit of BIM" (2008 p.4), which is matched by Suermann's findings that there is a lack of empirical data to back up the adoption of BIM (2009 p.24). The responses of the construction main contractor participant further support these findings, as they believed it was difficult to quantify the benefit of adopting BIM, both in terms of gained profit margins, or accelerated project durations. The only actual evidence the main contractor had supporting its use of BIM was anecdotal suggestions from site supervisors and project managers that the projects where BIM was used had run more smoothly. The likely reason behind this lack of data is that BIM is relatively young technology in New Zealand. Suermann's report of 2009 made an initial step into producing quantitative data on the benefits of BIM, and was successful primarily due to the large number of potential BIM case study projects available in the United States and elsewhere overseas. Based on the services engineering participants estimate of approximately only 50% of their projects using BIM, and the main contractor using it only on their negotiated design and build projects, it would appear the number of projects in New Zealand making use of BIM is still too small to produce any meaningful quantitative data that could be further researched.

4.3.4 Change in design process and external drivers

The use of BIM shifts more design and engineering work towards the front end of a project, as was pointed out by the structural engineering participant. Whereas previously during the concept design phase, an engineer could have used a simple series of lines with an appropriate label to represent a beam in two dimensions, they must now know exactly what size and profile that beam is in order for the modelers to create an accurate BIM model. This is in line with the findings of the Constructing Excellence pathfinder project case study, which goes on to explain a "shift in fee structure will be required to reflect this" (2008 p.4). Such a change in fee structure has already been undertaken by the architecture participant, who explained "we're changing our feeing structures now….. but it's a learning process for the clients to realize they're going to be paying a bit more upfront…." Further to this, the architecture participant went on to describe how with "some of the commercial clients it does take a bit of encouragement" to get them to agree to a higher proportion of fees near the start, compared to government clients, who are "very much knowledgeable and interested" in the use of BIM on their projects, and are willing to meet the costs of BIM to gain its benefits.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

At this stage it appears that the Auckland AEC industry is only scraping the surface of what BIM is capable of. Instead of making use of the full n-D capabilities of BIM, most users are currently using it only as a 3D and basic 4D visualization and coordination tool with only some venturing the step further into 5D cost modeling.

The findings of this study are comparable and confirm the findings of two surveys conducted by the Centre for Integrated Facility Engineering at Stanford University in 2006 and 2007. The 2007 survey involved 171 respondents from a broad mix of geographic locations throughout the US and the rest of the world, business sizes, project types, and technical disciplines. They provided a broad and representative cross-section of all parties in the AEC industry, such as architecture, structural and services engineering, and construction management, which is very similar to the participant selection model in this study. The survey data indicate that the majority of users operate within the Visualization and Prediction phase consisting of 3D clash detection, architectural design, space utilization and 4D clash detection. A significantly smaller number of users operate within the Integration and Automation phase, which consists of more advanced and sophisticated methods, such as cost estimation, structural, safety, and energy analysis.

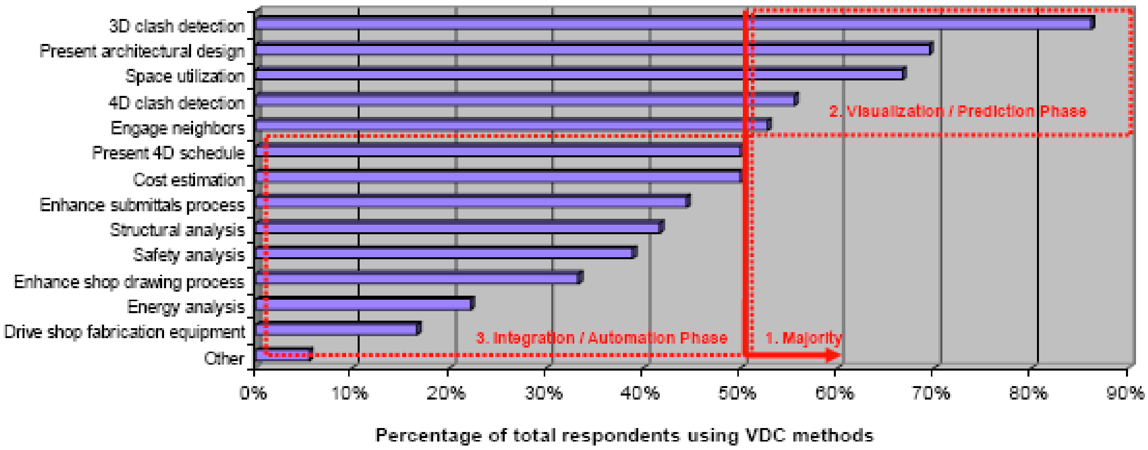

Figure 2: CIFE survey results – Business Purposes for VDC (Virtual Design and Construction) and BIM (Building Information Modelling) at individual organizations (Gilligan & Kunz 2007 p. 22)

The most common benefit found by the participants of this study was that of improved coordination between design disciplines, and the production of more accurate construction documents in a faster timeframe. The improved coordination also ensures the construction process runs more smoothly through fewer clashes, better buildability, and fewer requests for information from the construction contractors.

The main barrier preventing the uptake of BIM at this point is the change in design and construction process required. Commercial clients like and appreciate the use of BIM but in many cases require “encouragement” to invest in the higher design fees near the start of a project that BIM will cause. This is unlike government clients who were found to be “knowledgeable and interested” in having BIM used on their projects. Obviously as the knowledge of BIM that various clients have increases, more will become aware of the benefits associated with its use. The barriers of cost and staff training were not as significant as was described by the literature (Gilligan and Kunz 2007, Holness 2006) as for most sectors it was a commercial business decision to adopt BIM that would improve productivity and profit long term.

What has been made clear is that to make full use of BIM in the Auckland AEC industry, the whole process of design and construction must change. Fee structures must be skewed to match the greater workload of BIM near the start of a project, staff must be further trained and upskilled in the use of BIM, and a more collaborative approach must be taken to design, shifting to an integrated process where the various design disciplines work together more closely, both between themselves and the construction contractors. Currently, the most common method of procurement in New Zealand is the traditional tender (58%) (Zuo et al. 2006 p.3) which does not lend itself as much towards integration and teamwork as procurement systems such as design and build, or partnering/alliancing. This type of procurement system leads to those involved in the design and construction teams "[working] towards individually defined objectives that are often in conflict with one another" (Baiden et al. 2006 p.14), in stark contrast to what BIM aims to achieve.

5.1.1 Key benefits of BIM in the Auckland AEC industry

- Better construction document coordination.
- Faster document production.
- More accurate document production.
- Improved clash detection.
- 3D/4D visualization.
- Designers becoming more knowledgeable in the construction process.

5.1.2 Key barriers to BIM in the Auckland AEC industry

- More substantial design and engineering work required earlier.
- Drafting staff require more knowledge of the building process and require more design and engineering skills.
- Design process paradigm shift.

5.2 Recommendations

For the use of BIM to take off in the Auckland AEC industry, a further paradigm shift must take place, in making the design and construction process truly integrated and collaborative in nature. Procurement methods such as design and build, promote such an integrated design and construction process where the construction contractor is also the entity driving the design process. Similarly, project alliances also have such benefits of integration and collaboration. The recommendation is for the industry to more frequently adopt such procurement methods in order to promote the integration of the design and construction teams.

REFERENCES

Azhar, S., Hein, M., & Sketo, B. (2008) "Building Information Modeling (BIM): Benefits, Risks and Challenges." *In proceedings of the 44th Annual Conference Associated Schools of Construction.* Retrieved from http://ascpro0.ascweb.org/archives/cd/2008/paper/CPGT182002008.pdf

Baiden, B.K., Price, A.D.F., & Dainty, A.R.J. (2006) "The Extent of Team Integration within Construction Projects." *International Journal of Project Management*, 24(1), 13-23. Retrieved from http://www.sciencedirect.com.

Constructing Excellence. (2008) "Pathfinder Project: The Plaza Shopping Centre." Retrived from http://www.constructing.co.nz/files/Pathfinder%20Projects/The%20Plaza/PP3B109%20The%20Plaza%20Case%20Study%201108.pdf

Creswell, J.W. (2007) "Qualitative Enquiry and Research Design", Sage Publishing, London.

Denscombe, M. (2007) "The Good Research Guide for small scale social research projects", Open University Press, New York.

Gilligan, B., & Kunz, J. (2007) "VDC Use in 2007: Significant Value, Dramatic Growth, and Apparent Business Opportunity", Report No. TR171, Centre for Integrated Facility Engineering, Stanford University, Stanford. Retrieved from http://www.stanford.edu/group/CIFE/online.publications/TR171.pdf

Holness, G. (2006) "Future Direction of the Design and Construction Industry: Building Information Modeling." *ASHRAE Journal*, 48(8), 38-46. Retrieved from http://web.ebscohost.com

McNamara, C. (2009) "General guidelines for conducting interviews." Retrieved from http://managementhelp.org/evaluatn/intrview.htm

Suermann, P. (2009) “Evaluating the impact of building information modeling (BIM) on construction”. Doctoral dissertation, University of Florida. Retrieved from http://etd.fcla.edu/UF/UFE0024253/suermann_p.pdf

Turner, D.W. (2010) “Qualitative Interview Design: A Practical Guide for Novice Investigators.” *The Qualitative Report*, 15(3), 754-760. Retrieved from http://www.nova.edu/ssss/QR/QR15-3/qid.pdf

Woo, J. H. (2007) “BIM (Building Information Modeling and Pedagogical Challenges.” Retrieved from http://ascpro0.ascweb.org/archives/cd/2007/paper/CEUE169002007.pdf

Yan, H., & Demian, P. (2008) “Benefits and Barriers of Building Information Modeling.” In *proceedings of the 12th International Conference on Computing in Civil and Building Engineering.* Retrieved from http://www-staff.lboro.ac.uk/~cvpd2/Publications.htm

Zuo, K., Wilkinson, S., Le Masurier, J., & Van der Zon, J. (2006) “Reconstruction Procurement Systems: The 2005 Matata Flood Reconstruction Experience.” Retrieved from http://www.resorgs.org.nz/IREC%20Conference%20Paper%20Zuo.pdf