

BIM 2010: THE BENEFITS AND BARRIERS FOR CONSTRUCTION CONTRACTORS IN AUCKLAND

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ABSTRACT

Building Information Modelling (BIM) is the process of using computer software to create object-oriented, parametric models of buildings from which useful data can be retrieved. BIM can be used either collaboratively or under a traditional procurement structure, however collaboration is required to realise the full potential of the process.

Building Information Modelling represents an opportunity for main contractors in Auckland to counter the productivity losses that have been experienced in the New Zealand construction industry. Despite this, the adoption of BIM technologies by main contractors in Auckland appears to be much slower than in the United States or Europe where a large number of benefits have been documented as stemming from the use of the process. Further adoption of BIM in Auckland will be dictated both by real benefits and barriers and perceived benefits and barriers.

By conducting seven semi-structured interviews with medium to large commercial main contractors operating in Auckland this exploratory research has allowed a comparison between the benefits and barriers experienced by foreign contractors with the experiences and perceptions of medium to large main contractors operating in the Auckland construction industry towards BIM.

Although a number of the surveyed main contractors were already using BIM technologies, the research has found that their level of engagement with the Building Information Modelling process has been relatively low. This has meant that the intensity of both the benefits and the barriers is lower than those documented in the predominantly foreign literature. All the surveyed contractors felt that the use of BIM technologies would grow within the Auckland market, but also that the drive towards this growth will not come from main contractors.

CONFIDENTIALITY STATEMENT

The author has agreed that all personal and company names of participants in this research will be kept confidential.

The confidentiality of the participants has been maintained by referring to the participants and their companies by labels. Some details of projects being worked on by the participants have also not been reported to further limit the possibility of identifying the participants.

PUBLICATION AGREEMENT

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LIST OF ABBREVIATIONS

AGC Associated General Contractors of America

BIM ABuilding Information Model or Building Information Modelling

IPD Integrated Project Delivery

LTI Lost Time Injury

VDC Virtual Design and Construction

1 INTRODUCTION

This chapter outlines the rationale behind this research, establishing the context within which it is undertaken and its significance to the Auckland construction industry.

1.1 Background and Rationale

The productivity of the New Zealand construction industry has decreased both in real terms and in comparison with the productivity of other industries (Building and Construction Sector Productivity Taskforce, 2009). The Building and Construction Sector Taskforce attributed the decrease in productivity to a lack of innovation in construction processes. The use of BIM provides the opportunity for an innovation in the process of construction project delivery and was listed as one of five “opportunities for breakthrough improvements” in construction sector productivity in the United States (National Academy of Sciences, 2009).

Building Information Modelling (BIM) is the process of using computer software to create object-oriented, parametric models of buildings from which useful data can be retrieved (Associated General Contractors of America, 2006). The individual 3D objects within the model are labelled and assigned parameters which allow for the interrelationship between building components to be analysed and linked to, amongst other things, time and cost (Eastman, Teicholz, Sacks, & Liston, 2008).

A major study conducted by McGraw-Hill in the United States reported that in 2009 half of the surveyed contractors were using BIM technologies (McGraw Hill Construction, 2009). The New Zealand construction industry appears to have been much slower to adopt BIM technologies despite the many documented benefits experienced by its users overseas (Snijders, 2008).

Whilst a large body of foreign literature exists there is a lack of research directly investigating the New Zealand context, which may be symptomatic of the rarity with which BIM is undertaken in New Zealand. Foreign studies have documented the benefits and barriers that construction contractors have faced in adopting BIM technologies primarily through case studies and surveys. It appears that internationally the benefits and barriers are similar with only minor differences related to geographical location.

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1.2 Purpose of this Study

The research question is:

BIM 2010: What are the benefits and barriers to the adoption of BIM technologies by medium to large commercial main contractors in Auckland?

The study represents a snapshot of the Auckland industry as it is expected that perceptions towards and experiences of BIM will change for main contractors as the use of the process becomes more prevalent.

By establishing both the benefits and barriers experienced by main contractors in Auckland and the perceived issues relating to the technology the differences between

the foreign and the New Zealand context can be established as well as highlighting the difference between real and perceived issues.

In order to contextualise the study a clear definition of BIM will be developed as well as perceptions relating to the growth of BIM and the drivers thereof. A review of the available literature will be carried out and from the issues discovered an interview schedule will be developed.

1.3 Scope of the Research

The research is exploratory as it appears that no similar research has been conducted in New Zealand. The study investigates medium to large sized main contractors operating in the Auckland commercial construction industry, not including civil construction contractors. A sample of seven employees representing five construction contractors was chosen using the purposive sampling technique (Bouma, 2000). Employees of companies currently using BIM technologies and employees of those that are not are surveyed in order to provide increased validity and reliability to the study (Burns, 1997). The employees work either in senior management roles or in roles directly utilising BIM technologies. This achieves a greater depth of understanding of the issues related to BIM.

1.4 Report Presentation

The report will be structured in the following format:

Chapter 2: Presents and critiques the available literature relating to the use of BIM by construction contractors.

Chapter 3: Identifies what data is required in order to answer the research question and subsequently establishes and defends the method of data collection and analysis used by the study.

Chapter 4: Presents the findings of the survey.

Chapter 5: Analyses the results presented in chapter 4 and compares them to the results of the literature review.

Chapter 6: Provides the conclusions reached by the research as well as discussing the limitations of the study and areas that require further research.

Appendices: Supporting information related to the research.

2 LITERATURE REVIEW

2.1 Introduction

There is a large amount of literature available pertaining to Building Information Modelling however the overwhelming majority of this is sourced from and concerned with the United States. This is attributable to the prevalence of BIM use in the US construction industry and the size of the US market (McGraw Hill Construction, 2008). The adoption of BIM technologies by construction contractors in Auckland appears to have been much slower than in the United States (Snijders, 2008), which has meant that there is a very limited amount of literature available that directly addresses the New Zealand context. The international literature is applicable in assessing the benefits and barriers of BIM to contractors in Auckland as it is apparent, through researching literature from multiple countries, that the reported benefits and barriers remain similar regardless of location.

2.2 BIM Defined

There are a number of different definitions of BIM presented across the literature. As with many new technologies definitions emerge as use becomes more prevalent, and familiarity with concepts and attributes becomes greater. The term BIM can be used as either a noun, describing a building information model or as a verb describing building information modelling; the process of creating a building information model (buildingSMART, 2010). Many of the definitions view BIM from a particular stance; architects concern themselves primarily with the design aspect of BIM, engineering firms with the structural application of BIM and so on (Aranda-Mena, Crawford, Chevez, & Froese, 2009).

A building information model is defined by the Associated General Contractors of America (2006, p. 3) as:

a data-rich, object oriented, intelligent and parametric digital representation of the facility, from which data and view appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility.

The above definition of a building information model will be used for this research paper as it defines the level and form of information to be contained within a building information model without extending into the method of creating the model. Essentially it focuses on the end product, the model, as opposed to the process of creating the model. The detail incorporated in this definition means it is much clearer than that utilized by the National Institute of Building Information Modelling which refers to BIM simply as “a digital representation of physical and functional characteristics of a building” (2010, p. 1).

As with the definition of a building information model there are a range of different views as to what building information modelling means. Whilst there is a general acceptance that building information modelling is the process of creating a building information model, the variations occur in defining the nature of the process (Aranda-Mena et al., 2009). Many sources, including The National Institute of

Building Information Modelling view collaboration as an inherent requirement of the building information modelling process, with different stakeholders working together to enable the creation of a “data rich model that can be shared throughout the life of the building” (NBIMS, 2010, p. 1). This definition describes the best practice use of BIM, however it may be biased as one of the key aims of the Institute is to promote the collaborative use of BIM. By defining it as an inherently collaborative process they are arguably attempting to control and direct the development of BIM as its use becomes more prevalent in the industry.

In order to reach its fullest potential the building information modelling process must be used in a collaborative way, however BIM can be carried out without utilising this project delivery method (VTT Technical Research Centre of Finland, 2006).

Many of the reviews of BIM and its performance do not highlight that currently BIM as a process is not undertaken within one single entity or piece of software. The process requires the creation of multiple models, one for the architectural design, one for the structural design and one for the services design. Further to this there is a delineation between BIM authoring software (used to create the models) and BIM analysis software (used to extract required data from the model) (VTT Technical Research Centre of Finland, 2006). Once an architectural model is created for example, separate, stand alone pieces of software are required to extract the quantities from within the model (Katz & Crandall, 2010).

The development of software technology applicable to the construction industry has resulted in the creation of a number of new terms (Aranda-Mena et al., 2009). While the term BIM is widely used in the industry and the literature, synonyms such as nD modelling, product modelling and Virtual Design and Construction (VDC) have also developed (Aranda-Mena et al., 2009; Fischer & Kam, 2002; Ho & Matta, 2009). VDC refers more specifically to the process of using a building information model to build a facility in a computer generated environment and includes the use of time based review of construction methods (Fischer & Kunz, 2004).

Integrated Project Delivery (IPD) is another term that has been developed alongside BIM. Paraphrasing Yoders (2010) IPD refers to the collaborative structure of a project team across disciplines, whereby contractors work together with engineers, architects and owners to complete project deliverables. As discussed above, some definitions include IPD as a characteristic of a building information modelling process however it is not inherently linked with BIM. Regardless of this, BIM does provide a platform for facilitating an increased level of collaboration in the industry and for the best results from a BIM process to be achieved a collaborative structure must be used, hence the two terms are often associated in the literature (Katz & Crandall, 2010).

One of the key elements in the definition of a BIM is that the model is object oriented and parametrically designed (Associated General Contractors of America, 2006). Parametric modelling places constraints over objects and elements that govern the characteristics and adjustments that can be made to that element. The parameters that are placed on the object include spatial coordinates that allow the location and positioning of any object to be examined. The parameters are defined in a hierarchy dictating that if one element or object around it changes the change will also need to

be enacted on surrounding objects. For example if the parameter is set that a door way must be centralized in a wall, and the designers subsequently increase the length of the wall, the door way will reposition itself automatically. The rules to which the design is carried out can also be preset to ensure that any design change meets the building code with any deviations from code requirements being flagged. To paraphrase Eastman (2008), the relationship between elements that is facilitated by parametric modelling is one of the key differences between this type of design and 3D design, under which any change would have to be carried out on each individual element.

3D modelling represents a component of BIM however the two modelling methods are not synonymous. Related to and in addition to the difference noted by Eastman, a building information model contains a much greater level of information than a 3D model, including the specifications and properties of individual elements contained within the BIM. While 3D modelling allows for an increased level of visualisation it does not facilitate many of the other benefits BIM presents through the ability to extract a high level of accurate information from the model that can be directly used for construction or costing (Eastman et al., 2008).

‘Object oriented design’ refers to the information in the design not being compiled from lines and vectors (as it would be utilising 2D CAD drawings), but rather as three dimensional objects that exist virtually with inherent characteristics that can either be designed within the model or imported from stand-alone databases (Bevill, 2010).

‘4D modelling’ refers to the creation of a building information model which links the construction works associated with elements of the building to time. The construction of a building can hence be viewed virtually allowing not only for an increased level of programme visualisation, but also for the sequencing of construction activities to be proposed and analysed before being implemented on-site. Areas of the site that will be developed during particular phases can be identified and any preliminary works or site logistics can hence be thoroughly planned (U. S. General Services Administration, 2009).

The fifth dimension (5D) in a BIM model links the model to cost, as the 4D links it to time (Snijders, 2008). This allows the objects within the model to be quantified automatically through the use of BIM analysis software (Popov, Migilinskas, Juocevicius, & Mikalauskas, 2008). While this is a major application of the BIM process, the focus of this research centres on construction management and hence the 5D element of BIM is only considered when there are identifiable impacts on the construction management field.

2.3 Prevalence of BIM use by Contractors

Snijders(2008) claims that Lockwood Naylor’s use of BIM technologies on the construction of the Palmerston North shopping plaza was one of the first in New Zealand, however this claim is unsubstantiated. The lack of available literature on BIM use in New Zealand may be a symptom of the rarity of use currently in the New Zealand construction industry.

In the United States BIM use is much more accurately documented. Seminal surveys of the US construction market by McGraw Hill have resulted in Smartmarket reports in 2008 and 2009 detailing the use of BIM (2008, 2009). The results in 2009 documented that half of the surveyed contractors in the US were using BIM or BIM related tools representing four times the level of use recorded in the survey two years earlier. The increase in levels of use is expected to continue with 71% of surveyed contractors reporting positive returns on investment, 52% believing that there is further value to be gained by using BIM as experience grows and BIM being identified as one of five strategies to be followed in order to increase construction productivity by the National Institute of Standards and Technology (McGraw Hill Construction, 2009).

The importance of BIM in the development of the construction industry in the US is not only exemplified in the McGraw Hill survey statistics but also simply in the number of organizations and programmes formed to try to control the development and implementation of BIM in the industry. The creation of the National Institute of Building Information Modelling Services, the US General Services Administration's 3D-4D BIM program, the American General Contractors implementation guide and task force for contractors all point to the growing importance of BIM in the industry (Associated General Contractors of America, 2006; NBIMS, 2010; U. S. General Services Administration, 2010).

A survey of 67 companies conducted through Loughborough University in the United Kingdom suggested that BIM was being used by approximately twice the number of construction industry companies in the US as in the UK (Yan & Damian, 2008). No reason is offered by Yan and Damian for the difference. McGraw Hill are currently undertaking a survey of the scale of the Smartmarket reports discussed above addressing the UK and European construction markets, however the results are not yet available (B.S.R.I.A., 2010).

A 2007 study conducted by the Finnish Funding Agency for Technology reported that 45% of non-design based construction industry companies in Finland had participated in projects collaboratively utilising building information models (Howard & Björk, 2008).

2.4 Construction Sector Productivity

Contrary to the efficiency gains in most other industries the productivity of the New Zealand construction industry has declined over recent years. A Department of Building and Housing taskforce established to assess the productivity of the New Zealand industry found that not only was the industry losing ground against other sectors of the economy but also against foreign construction industries (Building and Construction Sector Productivity Taskforce, 2009).

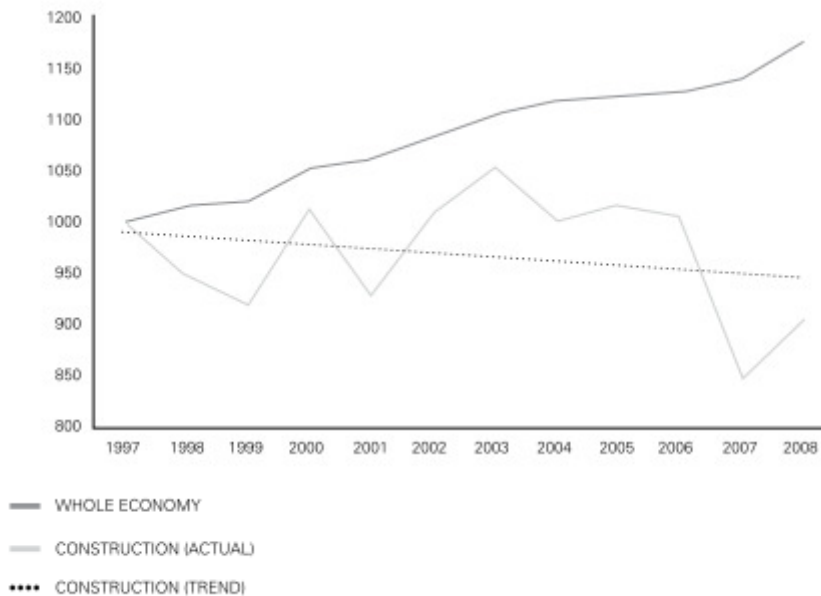


Figure 1 Labour Productivity of the economy and construction sector compared (Building and Construction Sector Productivity Taskforce, 2009)

Within the report the Taskforce suggests that while some innovations have been made that improve construction efficiency (mainly through prefabrication) the main innovations utilized by the industry have been centred around building materials, not methods, which has led to an increase in quality, not productivity (Building and Construction Sector Productivity Taskforce, 2009). A similar study in the United States also described losses in efficiency and in making recommendations to counter this suggested that BIM was one of five “opportunities for breakthrough improvements” in construction sector productivity (National Academy of Sciences, 2009). Another of the five opportunities listed in the report is an increase in off-site fabrication, which as discussed below is available through a wider use of BIM technologies.

One of the key issues needing to be rectified in order to increase the productivity of the New Zealand construction industry is the lack of collaboration in the procurement of projects. The focus on cost rather than value currently being pursued by clients limits the input of the contractor at the design stage and hence limits the potential construction phase efficiencies to be gained (Building and Construction Sector Productivity Taskforce, 2009). While BIM cannot change the culture of procurement it does provide a framework and platform for an increase in collaboration (Katz & Crandall, 2010).

2.5 Distinguishing BIM benefits from Collaboration benefits

Before examining the benefits and barriers that BIM users have experienced it is important to distinguish the difference between those that are a direct result of BIM use and those which are a consequence of an increased level of collaboration on a project. The majority of the literature does not make this distinction, which may be due to the lack of clarity surrounding the meaning of the term BIM. BIM can be used as a platform to facilitate an increased level of collaboration however the benefits of

an increased level of collaboration should not be identified as benefits of BIM (Katz & Crandall, 2010). Throughout the literature it is clear that the higher the level of collaboration the greater the benefits that are achieved under a BIM process (Madsen, 2008). While there are benefits that are available under a traditional procurement model, such as the detection of clashes between building elements, the true potential of BIM will not be realized due to the lack of information sharing amongst the project team members, limiting the chance for buildability issues to be raised and changes to be made (Eastman et al., 2008). The McGraw Hill Smartmarket(2008)report found that 80% of contractors in the United States who are advanced in the use of BIM will convert 2D drawings into BIM if the project is not originated using the process. This suggests that sufficient benefits can still be achieved without early collaboration between designers and contractors to justify the costs incurred in the modelling process.

In 2007 The Associated General Contractors (2007) claimed that the majority of contractors will begin to use BIM on projects where the model is not fully open to information sharing between the stakeholders and that levels of information sharing will increase with exposure to and experience of the process.

Unrelated to collaboration but inherently linked to the above, the benefits created by using BIM increase as the experience of companies increases. As users become more technically adept they realize more fully the opportunities that the BIM process presents and hence are able to make the most of those opportunities (McGraw Hill Construction, 2008).

2.6 Benefits

2.6.1 Visualisation

BIM's three dimensional component allows for an increase in visualisation. Visualisation is important for contractors as it clearly identifies work that is required to be completed, thus limiting the chance of omitting work and also allowing the relationship between building elements to be defined. Complicated joints for example can be easily explained to trades through the ability to view the multiple layers of the element from a multitude of angles which can lead to fewer on-site mistakes (Associated General Contractors of America, 2006). Identifying more clearly the scope of works of subcontractors should also reduce the number of variations sought for works that were not originally allowed for (Fischer & Kunz, 2004).

The increase in visualisation that BIM offers can be experienced regardless of whether or not the process is being carried out collaboratively and can be achieved with a relatively low level of engagement with the model.

2.6.2 Prefabrication

Off-site fabrication can allow for a decrease in construction programme as completed items can be brought to site and fitted directly into place, with less sequential constraints imposed by on-site fabrication and assembly. The completion of prefabricated elements can occur concurrently with on-site works without hindering their progress, the arrival of the item being timed so as to occur at that time when the sub-elements are ready to accept the completed item. Efficiencies of prefabrication

are also gained through the ability to complete the works in a controlled environment unaffected by weather and with all the required equipment, positively affecting both time and quality (National Academy of Sciences, 2009).

The use of BIM technologies provides an increased opportunity for off-site fabrication due to the level of detail contained within the model (Eastman et al., 2008). Sawyer (2009) notes that in a case study of a US\$325 million hospital project the greatest efficiencies were gained by the ability of suppliers to increase the amount of materials and connections that could be completed off-site. Subcontractors were able to manufacture larger components and complete longer runs because of the accuracy of the model, requiring less work to be completed on-site.

The subcontractor can extract the information needed for prefabrication directly from the model, limiting the liability of the contractor and reducing the likelihood of errors due to data extraction from multiple sources (as would be required using traditional 2D drawings). This also decreases the time required to correctly assemble the information into a usable form and can hence positively affect procurement lead times for prefabricated items (Katz & Crandall, 2010).

While the focus of this paper is on the construction management applicability of BIM technologies to main contractors it is important to acknowledge that the efficiencies gained by the quantity surveying profession can also positively affect the construction management field as is noted above.

2.6.3 Improved Programming/Scheduling

By facilitating an assessment of construction sequencing possibilities and allowing an easier comparison of the current construction status to the schedule, 4D building information models allow for greater control over time (Fischer & Kam, 2002). '4D modelling' can also easily identify any items that will be required as part of the upcoming sequence of works, which affords the contractor the opportunity to ensure that off-site items will be ready in time so as not to hold up any works (McGraw Hill Construction, 2008).

Sufficient detail must be embedded in the model to allow for BIM's 4D capabilities to be realized. This includes temporary works, site logistics, correct object groupings and information relating to specifications. Without this level of detail the model is not accurate enough in order to conduct accurate scheduling or order materials for off-site fabrication (Eastman et al., 2008). The increase in data input does create additional work for the contractor however case studies suggest that this increase is outweighed by the benefits it affords (Post, 2008a).

Through incorporating the plant and temporary works into the model contractors are afforded the opportunity for a greater analysis of site logistics. For example, tower and mobile crane positions can be assessed to easily establish that all necessary locations can be reached, storage requirements of subcontractors can be positioned on the site and congestion on-site during intense periods in the construction programme can be more efficiently managed (Fischer & Kunz, 2004).

The level of visualisation that 4D phasing allows increases buy-in by subcontractors as coordination meetings which display animations of the work sequence provide proof of the logic of the activity flow much more than simple bar chart construction

programmes or multiple sequence drawings (Eastman et al., 2008). It also allows the contractor to more effectively communicate the importance of any particular work package for the schedule of the overall project (Fischer & Kunz, 2004).

2.6.4 Coordination

BIM creates consistency across the design documentation prior to construction work being undertaken as any inconsistencies will be highlighted within the models. This in turn increases quality on the site as a clear and definitive direction is given to the works and return visits for rework are hence limited (Snijders, 2008). Consistency between 2D drawings can only be established through inspecting multiple drawings and is prone to human error. Changes to 2D drawings must also be enacted across a number of drawings which further increases the chance of inconsistencies across the drawings (Eastman et al., 2008).

Linked to the increased data input requirements mentioned in the previous section it is important to note that the quality of the information that can be extracted from the model is only as good as that which has been input. In order for quality to be enhanced by utilising BIM technologies the design information that is input into the model must be accurate enough to be relied on by the contractor (McGraw Hill Construction, 2009).

One of the most documented benefits offered by BIM is the ability to detect clashes between building elements (McGraw Hill Construction, 2008). The ability to detect clashes between elements in the virtual construction of the facility rather than being discovered in the field leads to savings of both time and cost. This function of BIM is achievable regardless of whether or not the model is completed in a collaborative environment (Eastman et al., 2008). The detection of clashes is enabled by BIM through analysis software that can combine models and assess the spatial coordinates that are assigned to the objects (VTT Technical Research Centre of Finland, 2006).

2.6.5 More Efficient Communication

Improvements in communication across the various stakeholders in a construction project can limit the risk to which contractors are exposed by reducing lag time in the transmission of information and also minimizing miscommunications. Used collaboratively BIM can improve communication not simply through the speed with which information can be dispersed but also through the increased quality of the information that is dispersed (Associated General Contractors of America, 2006)

Through automatic updates of the model the need to update multiple 2D drawings and schedules in order to document a design change is minimized, or eliminated, depending on the level to which 2D drawings are utilized on the project. This means that the implications of design changes are presented to the contractor faster (Kaner, Sacks, Kassian, & Quitt, 2008).

BIM can enable a reduction of Requests For Information needing to be processed during construction. This can in part be attributed to the use of a collaborative working environment, which means that buildability issues are identified and addressed prior to the beginning of construction, however most issues will be discovered regardless of whether the model is completed under a collaborative nature or not as they will be flagged in the model as it is created (Fortner et al., 2008).

The use of BIM provides the contractor with a means for easily communicating that a building fits within a certain code. BIM programmes can prove compliance with LEED (Leadership in Energy and Environmental Design) in the United States (Azhar, Brown, & Farooqui, 2008). The use of the software largely limits the vast amount of information that must be manually collected and entered into the applications of the appropriate organization from which compliance verification is sought (McGraw Hill Construction, 2008). The associated decrease in repetitive data entry of the relevant design and construction information limits the liability of the contractor by ensuring that the majority of the information is taken directly from the model (Howard & Björk, 2008).

The increased level of data contained within the model provides communication efficiencies as the data required by a large number of users is contained within a single location. This means that rather than having to search through a number of 2D drawings and specification documents, parametric data, specifications and the like can all be located within the model (Associated General Contractors of America, 2006).

Further, a case study of BIM use in Finland has reported that 50% time savings were achieved in the design documentation stage through the use of existing libraries of object details that had already been modelled using BIM software, such as those offered by the Construction Specifications Institute noted below. The early completion by the designers in turn minimized the amount of time spent by the contractor drafting and allowed a greater amount of time to be spent assessing buildability and sequencing by the contractor, which allowed for a higher level of quality during the construction phase (Fischer & Kam, 2002). Eastman (2008) notes that the benefits experienced by contractors using BIM are enhanced if the contractor is involved early in the design process, generally following the Pareto Principal which dictates that the ability to implement changes decreases with time and the cost to implement changes increases with time.

The Construction Specifications Institute in the United States has begun development of an international object library from which universally applicable characteristics can be extracted; hence reducing the amount of time spent modelling. Modelling efficiencies may also be gained through Unifomat II and Omniclass, methods of categorizing elements within a model, which should provide greater opportunity to control and organize the data within a building information model (Construction Specifications Institute, 2010).

2.7 Barriers

2.7.1 Cost

In order for BIM to be adopted by a contractor there is a large investment required in updating both software and hardware and in the training of staff. Beck (2009) suggests that as a result of the initial start up costs, return on investment can take up to 4 years. This supports figures presented in the McGraw Hill (2009) report on the business value of BIM which reported that 27% of surveyed contractors in the United States reported a return on investment of between 10-25%, as presented in the graph

below. Although the responses appear spread across the spectrum of returns, this group represents the largest single group.

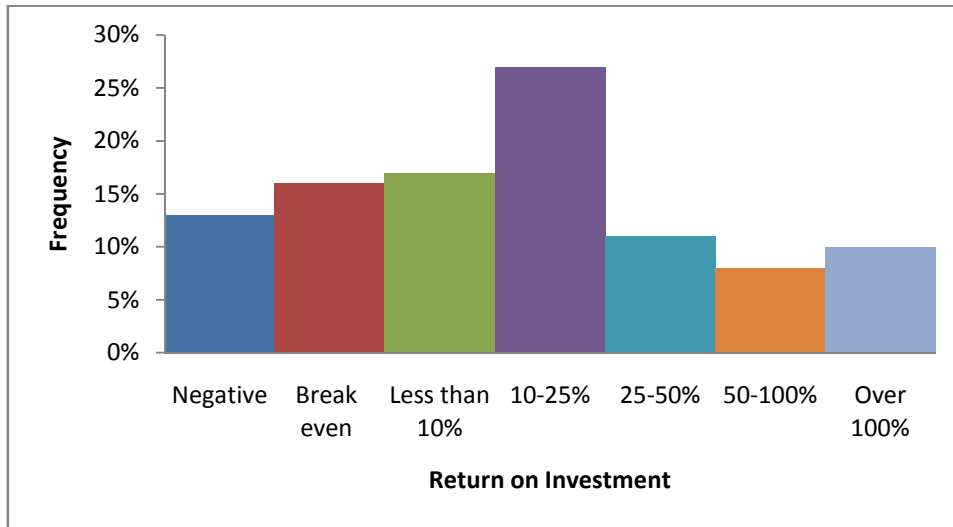


Figure 2 BIM Return on investment for contractors (Reproduced from McGraw Hill, 2009)

While it is generally documented that the initial cost of setting up for BIM is a constraint to the wider adoption of the technologies, Howard and Bjoerk (2008) suggest that there has been little investigation into the actual costs incurred by companies and that the area requires further exploration. Some costs can be established broadly through simply exploring the cost of the required software and hardware however the cost associated with changing culture and company methods will be difficult to quantify on an industry wide basis due to the difference in the changes required to incorporate BIM technologies into a company's processes (Associated General Contractors of America, 2006; VTT Technical Research Centre of Finland, 2006).

The current cost of a single seat on Graphisoft's ArchiCAD 13 in New Zealand, an architectural 3D BIM design tool, is \$8750 +GST. Graphisoft currently offer 2 day introductory and 2 day intermediate BIM courses for \$695 + GST each (Graphisoft, 2009). As such the costs of the software and training do not appear overly cumbersome when compared to the overall cost of delivering a construction project, despite the frequency with which the barrier is noted in the literature and the 2008 McGraw Hill study finding the cost of software and hardware upgrades in the top four barriers to a wider adoption of BIM (McGraw Hill Construction, 2008). This reinforces the point made by the VTT Technical Research Centre of Finland that the costs vary dependent on company and are difficult to quantify.

Lockwood Naylor, the contractor completing the Palmerston North Plaza Shopping Centre, reported that the increased cost of converting the 2D drawings into a building information model was offset by the savings achieved through its use, meaning that the process was cost neutral for the Lockwood Naylor on the project (Snijders, 2008).

2.7.2 Training

The McGraw Hill Smartmarket report (2009) offers conflicting information on the issue of training, stating that the initial cost and a lack of trained operatives were the largest barriers to the greater adoption of BIM technologies, but also that 50% of the survey respondents felt that the lack of training had little impact on the decision to adopt BIM technologies. The prevalence of the issue in the literature however underlines the importance of the lack of training as a barrier to the adoption of BIM technologies. In addition to this the 2008 McGraw Hill survey suggested that a lack of training was one of the four largest barriers to the wider adoption of BIM technologies (McGraw Hill Construction, 2008).

It is important to note that the current lack of training in the use of BIM software is not a result of a lack of opportunity but due to the novelty of the technology. Currently courses are available in Auckland in the programmes of all the major BIM authoring software suppliers- Graphisoft, Autodesk and Bentley (Autodesk, 2010; Bentley Systems, 2010; Graphisoft, 2009).

The lack of skills and knowledge that currently surround BIM require careful analysis of responsibilities within firms. If the decision is made to design a building using BIM the 2D drawing phase can be skipped. Completing the design in 3D may require using modellers who are skilled in the use of BIM software. If the initial design phase is completed in BIM it is important that the workers creating the model are not only proficient in BIM modelling but also understand engineering principles (O'Brien, 2008). Without knowledge of both areas it is likely that some of the buildability benefits BIM offers will be lost.

2.7.3 Liability

Stemming from their ownership and control of the design, in most construction projects the client is contractually obliged to ensure the accuracy of the design documentation. As such, the liability of the contractor is limited to completing the works as per the specification and drawings and does not extend to the design of the works itself, unless sufficient negligence can be proven (Katz & Crandall, 2010). Using a collaborative BIM process the contractor has significant input into the design process and access to the model, hence the clients' absolute control over the documentation may be lost (Azhar, Hein, & Sketo, 2008).

The increased input of the contractor into the design process facilitated by the collaborative use of BIM could be seen to increase the contractors' liability for the design (McGraw Hill Construction, 2008). It is important to note that this is a fundamental risk of collaboration as opposed to BIM. The barrier must however still be addressed as in its perfect state BIM should be used collaboratively and the use of BIM technology also provides a framework in which collaboration can be undertaken (Katz & Crandall, 2010).

Not only does collaborative BIM use potentially increase the liability of the contractor, it also makes responsibility for faults more difficult to establish. If BIM is being used in a collaborative structure multiple parties may be updating data within the model making it difficult to track which party is responsible for a change or

omission that causes a fault (Azhar et al., 2008). This could lead to the contractor being implied as the cause of faults again increasing their liability for the design.

The transmission of data between stakeholders in a construction project poses a very high level of risk for the party sending the information (Smith & Tardiff, 2009). This liability transcends the inputting of the data into the model and extends to the archiving of the model which must be done accurately at appropriate stages (VTT Technical Research Centre of Finland, 2006). Inherent within this but not directly identified is that the responsibility for the updating of the model should lie with a single entity or group within the project. If access to update the model is allowed to multiple parties it will become impossible to control the model and responsibility and liability for various issues will be difficult to establish, as is described above. The collaborative use of BIM will entail having a model that is accessible to all parties in the project but it is important that the access is limited to a read only function, with any changes to the model being approved and subsequently input by the appropriate party. This has been successfully done in the US and New Zealand where .pdf files of models have been created in order to allow various stakeholders to view the models but not edit them (Snijders, 2008; McGraw Hill Construction, 2008). As information that needs to be input into the model will be produced by multiple parties the information will have to be thoroughly checked prior to inserting the data which will incur costs (VTT Technical Research Centre of Finland, 2006).

When BIM is being used on a project in conjunction with 2D drawings it is necessary to define the relationship of the model to the contract documents. This is the same as any construction contract where it is important to define the hierarchy of project documentation so that when anomalies appear precedence can be decided (McGreevy, 2010). If the model is only provided for visualisation and to disseminate intent and cannot be relied on to establish that the contractor has completed the works as per the contract, many of the benefits of BIM will not be realized. In essence, if the contractor wanted to rely on the model for fabrication data they would need to create a new model from the contractually linked 2D drawings to ensure that the information could confidently be passed on to subcontractors to complete the works.

Whilst there is the potential for an increase in design liability for the contractor by utilising a collaboratively created BIM, it is important to note that there is a reduction of contractor liability in other areas. Due to the amount of data contained within the model the need for the contractor to extract the pertinent information required for subcontractors to produce shop drawings or fabricate products from 2D drawings is removed. The requirement to input information into project documentation required to prove compliance with either the building code or green star ratings is also negated thus limiting the liability of the contractor resulting from errors associated with repeated data entry (Howard & Björk, 2008).

The issue of liability in the United States has already, in part, been addressed through the creation of new contracts and addendums that are specific for use on projects utilising BIM. The American Institute of Architects has created contracts that are tailored towards collaborative BIM use, whereas the Associated General Contractors of America have been involved in the development of the ConsensusDOCS

Addendum. This addendum is for use on all BIM projects, not just where BIM is being used collaboratively, and defines the liability for design as lying with the party that changed the design (Yoders, 2008).

2.7.4 Ownership of the Model

As with an increase in contractor liability, issues related to ownership of the model are only apparent when BIM is utilized in a collaborative environment under which multiple parties are contributing to the model. Clearly if the model is produced and utilized solely for the benefit of the contractor the ownership will remain with them.

The issue of ownership occurs where proprietary design elements are input into the model and the model is subsequently available to other parties. If the amount of design information required to entail some form of ownership is not defined in the contract documents the ownership and rights to reproduce the model may not be easily established. Although the client would generally own the rights to the design the increased level of information contained within the model and the number of parties contributing this information to the model blurs the lines of ownership over the model. Azhar (2008) suggests that this risk cannot be countered by a single uniform rule and must be dealt with on a project by project basis assessing who will be providing information to the model and to what extent. Azhar (2008) correctly concludes that the guidelines for ownership at completion of the project must be established prior to the start of the project to not discourage open sharing of information that may result if this issue is not adequately addressed.

This issue can in part be resolved through the use of industry accepted standards for the ownership of a BIM model. In New Zealand Jasmx architects have developed a best practice document intended to guide the collaborative use of BIM. Jasmx propose that the intellectual property of families or systems within the model remain the intellectual property of the company that created the model (Jasmx, 2010). This document is however at present only a best practice draft and not an industry standard.

The disproportionate nature of the benefits is a minor constraint that hinders the further use of BIM by construction contractors. The party receiving the largest benefit from a building information model will generally be the owner of the building due to the ability to better manage the maintenance and facilities of the building over its lifetime, hence reducing cost. This benefit may be the direct result of the work of the contractor in providing or inputting data into the model and if this is not recognized in the contract documents the contractor will not receive compensation for the benefit they have provided the client (Howard & Björk, 2008). The method for overcoming the issue of ownership proposed by Katz and Crandall (2010) whereby the Building Information Model becomes one of the project deliverables provides a means for the contractor to seek compensation for the benefit to the client. Inherent within this strategy but not noted by Katz and Crandall however is that the owner sees the value in the model and is prepared to pay for the costs associated with the BIM process.

2.7.5 Interoperability

The International Alliance for Interoperability define interoperability as “an environment in which computer programs can share and exchange data automatically (without translation or human intervention), regardless of the type of software or of where the data may be residing” (Fischer & Kam, 2002, p. 14).

A lack of interoperability of BIM software programmes was the most frequently noted factor that needed improvement to increase the value of BIM in the 2009 Smartmarket survey, with 8 out of 10 respondents stating that it was an issue (McGraw Hill Construction, 2009)

Issues with the interoperability of software have arisen due to the development of software to satisfy differing requirements across different fields, rather than the software being developed as a single tool for use across the varying disciplines involved in a project. This is now evident in the lack of interoperability of BIM software (Thompson & Miner, 2006). Subsequently the problem has been exacerbated by the fact that software companies are attempting to establish large market shares, which discourages the creation of interoperable software packages (Fortner et al., 2008).

Fortner (2008) claims that the lack of software interoperability may even mean that potential project team members choose not to work together if they utilize different BIM programmes.

Even if the various BIM programmes are compatible with each other there is still the requirement to use multiple software programmes to carry out the BIM process. The AGC states that despite a contractor not requiring all of the programmes a list of potential software includes:

- Object-oriented 3-D modelling software for creating and manipulating models
- Engineering analysis software
- Rendering software
- Coordination software
- Estimating software
- Middleware
- Detailing software (BIM Forum, 2007)

Interoperability issues have been addressed by the Industry Foundation Classes (IFC) developed by buildingSMART (formerly known as the International Alliance for Interoperability). IFC is a free standard used to exchange data between different software applications used in the BIM process. This allows data transfer between software packages that are not only used for different applications but also that are provided by different software companies and hence counters the vast majority of interoperability issues (buildingSMART, 2008). In 2007 Robert Amor (2007) of the University of Auckland reported that the majority of large CAD suppliers internationally had applied the IFC standard and that the standard had been incorporated into government policy in some countries. However, contrary to this, Howard and Bjoerk (2008) and Eastman et al (2010) state that in the United States the

IFC standard has only been applied to test projects and has not enjoyed widespread use within the industry.

Interoperability requirements extend beyond the various software applications to the methods in which objects are labelled and categorised within a building information model. While these issues are also addressed by the IFC schema Eastman et al suggest that the schema is too broad and has not managed to overcome the problem (Eastman et al., 2010).

Alternatives to the IFC's exist in Uniclass, Process Protocol, Masterformat and the like, but Howard and Bjoerk (2008) suggest that IFC's are the standards that should be focused on and developed due to them offering the greatest potential for development (Katz & Crandall, 2010).

As mentioned above, in New Zealand Jasmax architects have begun developing a best practice document for the collaborative use of BIM that dictates how objects and families within a building information model should be labelled and organised. This document is currently being used on specific projects as a guideline however it remains in draft form and an industry standard has yet to be developed (Jasmax, 2010).

2.7.6 Cultural Issues/Resistance to Change

The cultural shift required for the successful implementation of BIM technologies has both an internal and an external component for contractors.

If BIM is to be used in a collaborative project structure there needs to be a fundamental shift in the way that procurement of buildings is approached. In the New Zealand market there is reluctance to move towards a more value centric approach (from the currently pursued cost centric approach) despite the fact that improvements in both cost and productivity have been documented as arising from a value centric approach (Building and Construction Sector Productivity Taskforce, 2009). This change needs to be driven by clients focusing on the whole life costs and utility of buildings as opposed to selecting contractors solely based on price in a competitive tender environment. Smith and Tardiff (2009) suggest that this fundamental shift in procurement strategy is the largest obstacle to a wider adoption of BIM utilising Integrated Project Delivery. Again while this change is not necessary for a limited use of BIM to be implemented by construction contractors it is a requirement for the full benefits of BIM to be achieved.

The movement towards a more collaborative method of project delivery also creates difficulties in cross company communication methods. Companies have inherent cultures, values and goals that may not be consistent with those of other stakeholders in the project team. This can cause conflict between the project team and presents another obstacle in the development of a wider use of a collaborative BIM process (VTT Technical Research Centre of Finland, 2006).

Further to the required contractual structure changes there is the need to adjust the fee structure on projects utilising BIM, regardless of whether the technology is being used collaboratively or not. Using BIM means an increase in planning and modelling at the start of the project, hence requiring that the fee structures will have to be front end loaded. This requires that clients are satisfied that the BIM process adds value to

their building as larger payments will need to be made to the contractor before the beginning of work on site (Snijders, 2008)

On an internal level contractors will have to overcome resistance to change within their own organizations. The change will need to permeate through all levels of the organization, including not only senior management support but also buy-in from site level workers. Senior management support is required to finance the initial cost of implementation and also ensure that the roles and responsibilities are assigned correctly within the firm (Sacks & Quitt, 2008). Senior management buy-in was noted by the 2008 McGraw Hill study as one of the top four largest barriers to the wider adoption of BIM technologies in the United States, along with training and the cost of software and hardware (McGraw Hill Construction, 2008). This is likely to be due to the authority of senior management to propose or affect procurement of BIM related software and hardware, which directly dictates the frequency with which the process is adopted.

The requirement to implement BIM processes at a site level means that employees with entrenched values who have little knowledge or skills in information technology must be convinced of the benefits of BIM. In a case study of Tocci Construction in the United States Post (2008b) documented younger workers skilled in the use of BIM being successfully paired with experienced superintendents and foremen in order that both construction and technological knowledge are combined in implementing the BIM process at a site level. The need to change the communication methods of superintendents to subcontractors was also identified, as the presence of the BIM did not automatically mean that it was used.

2.8 Summary

This chapter has reviewed the benefits and barriers of a wider adoption of BIM technologies for main contractors as set out in the available literature. The research has revealed that there is very little literature available that directly addresses the New Zealand context. The largest pockets of use appear to be in the USA and Finland, with seminal studies having been conducted in the United States. There do not appear to have been any studies done on the prevalence of BIM use in New Zealand.

Many definitions of BIM exist, varying in complexity and scope. This chapter has established a definition to be used for the purpose of this research. The benefits of BIM use are well documented and depend on the method and time of use, with increased benefits presenting themselves through the collaborative use of BIM and through early contractor involvement in the design stage. While many barriers to wider adoption of BIM technologies also exist some of these are symptomatic of the novelty of the technology and are already being addressed and overcome by BIM users overseas.

3 METHODOLOGY

3.1 Introduction

This chapter describes the process used to collect data to establish the benefits and barriers of using BIM technologies for medium to large main contractors in Auckland. The research strategy is defined and its applicability to the subject matter established.

3.2 Research Design

This research has been conducted to establish the perceptions towards, and experiences of, BIM technologies by main contractors in Auckland. This allowed the triangulation of the results with the findings of the literature review in order to establish the similarities and differences between the New Zealand and foreign context (Burns, 1997). Triangulation is “the use of two or more methods of data collection in the study of some aspect of human behaviour” (Burns, 1997, p. 324).

The research question is:

BIM 2010: What are the benefits and barriers to the adoption of BIM technologies by medium to large commercial main contractors in Auckland?

In order to be able to answer this question a definition of medium and large main contractors as well as the geographical area of Auckland needed to be developed. This provided a context in searching for participants, limiting the potential candidates to the scope defined within the research question. Time is also relevant to the research, as perceptions towards new technologies are likely to change as the technology becomes more commonplace.

It is important to note that perceived benefits and barriers to the adoption of BIM can influence a company’s decision as to whether or not they adopt BIM technologies, regardless of whether the barrier actually exists and has been experienced or not.

Exploratory research does not seek to prove a hypothesis but rather to discover a situation as it currently exists (Naoum, 1998). This research is exploratory as it appears not to have been conducted in Auckland before. While similar studies have been undertaken overseas the situation may vary due to geographical location. The perceptions of BIM in the New Zealand construction industry remain relatively unknown.

The research is cross sectional rather than longitudinal because it investigated the current state of perception, as opposed to investigating it over a period of time (Burns, 1997). As stated above, the influence of time over the perceptions towards BIM by the Auckland construction industry is expected to be strong.

3.3 Qualitative Research

Research is often defined as being either quantitative or qualitative. Quantitative research as defined by Creswell is “an inquiry into a social or human problem, based on testing a hypothesis or a theory composed of variables, measured with numbers, and analysed with statistical procedures, in order to determine whether the hypothesis or the theory hold true” (as cited in Naoum, p. 38). This type of research

method is not appropriate to address the research question as it examines hard, clearly defined issues. The aim of the research is to establish what the current perceptions and issues relating to the use of BIM are, as opposed to examining the frequency of the occurrence of specific issues. A quantitative study could therefore be too shallow, examining the surface of the issues but not allowing the opportunity to fully explore the complex relationship of benefits and barriers related to the use of BIM technologies. For this reason a qualitative approach to the research was adopted.

Qualitative research as described by Burns (1997, p. 295) is appropriate where “variables [are] complex and interwoven; difficult to measure”. The data collected within a qualitative study can be defined under two categories; exploratory or attitudinal (Naoum, 1998). The information collected within the interviews is largely attitudinal, being used to assess the “‘perception’ of a person, towards a particular object” (Naoum, 1998, p. 41). The interviewees were asked about their opinions of BIM, as their attitudes towards its benefits and barriers can be seen as the driving factor behind its use or lack thereof.

Despite this, part of the collected data may be defined as exploratory. Zikmund suggests that exploratory research is conducted for three reasons: “diagnosing a situation, screening alternatives and to discover new ideas” (as cited in Naoum, 1998, p. 40). As discussed above the aim of the research is to establish the perceived barriers and benefits of adopting BIM technologies, the success of the research is therefore inherently linked to the first and last reasons identified by Zikmund.

3.4 Interview Survey

The best method for establishing the perceptions of a targeted group is the interview survey. This is especially applicable to this research topic as the data collected is expected to be “complex and subtle” (Denscombe, 2007, p. 174).

There are 3 key types of interview that can be conducted:

- Structured interview
- Semi-structured interview
- Unstructured interview (Denscombe, 2007)

The semi-structured interview was selected for the purpose of this research because the researcher needed to gather data on specific themes but did not wish to exclude the possibility of uncovering new themes not identified as part of the literature review. This method “permits greater flexibility than the closed-ended type and permits a more valid response from the informant’s perception of reality” (Burns, 1997, p. 330). The structured interview follows a stricter question and answer format than the semi-structured, as the researcher administers questions in a set order and accepts answers following the same fashion. The more closed questioning approach can stifle the development of new ideas and is therefore not appropriate for this research. The semi-structured interview’s use of open ended questions allowed for the discovery of new barriers or benefits associated with BIM. The use of an interview schedule on which the interview was based, ensured that the documented issues are also covered. An interview schedule differs from a questionnaire in that a participant reads and answers the questions in a questionnaire without the presence

of the researcher, an interview schedule is administered face-to-face (Bouma, 2000). The unstructured interview maintains a more fluid format than the other two interview structures, however cannot be guaranteed to cover issues that are deemed essential for the success of the research (Denscombe, 2007).

The interviews were conducted face-to-face and recorded so that the researcher only had to take minimal notes and could therefore take a more active part in the interview (Burns, 1997). Field notes were taken to note non-verbal communications that may not be apparent when the recording of the interview was reviewed. The advantage of face-to-face interviews is that the collected data can be expected to hold a greater level of detail than is collected in the postal, internet or telephone interview methods (Denscombe, 2007).

One of the keys to the success of the research was to ensure that the correct person within the selected firm was interviewed. The interviews were carried out with two distinct types of employee:

- Senior management responsible for overseeing multiple projects
- Technical staff currently working with BIM models.

Senior management staff were selected as they will be central to the adoption of BIM technologies within an organization and were expected to be aware of the strategic direction of the surveyed companies. Staff members currently using BIM technologies were surveyed as they were expected to have a greater level of technical knowledge of the issues associated with BIM technologies than senior managers and should hence provide a different perspective. The face-to-face interview ensured that the selected employee was interviewed, as opposed to the telephone, postal or internet surveys whereby the completion of the survey may be delegated by the participant to a different employee (Denscombe, 2007).

An advantage of the interview method of data collection is that it has a higher response rate than other methods of research (Naoum, 1998). High non-response rates may skew the results of research, which can be especially problematic if the reasons for the non-response cannot be identified and analysed (Denscombe, 2007). Any non-respondents using the interview method can be identified and analysed in order to discount a bias that could be created by non-responses.

One of the main disadvantages of the personal interview method of data collection is that the interviewee can be influenced by the bias of the interviewer (Naoum, 1998). By expressing opinions relating to the barriers and benefits discovered in the literature review the researcher could have lead the participants to answer questions in a way that supports the findings of the literature review but is not a true representation of the opinion of the interviewee. In order to minimize the chance of this occurring, the purpose of the research was clearly stated prior to the start of the interview. This provided the respondent with the context within which they were being interviewed and also allowed the researcher the chance to establish their professionalism and build up rapport, both of which are important in collecting attitudinal data (Fellows & Liu, 1997; Naoum, 1998). The researcher was also well presented, polite and punctual (Denscombe, 2007).

A case study approach was also considered as the data collection method for the research, however the interview method allowed employees of companies using BIM and companies not using BIM to be surveyed, giving a broader perspective as to the benefits and barriers. It is likely that contractors already using BIM have a more positive view of the technology and hence undertaking a case study on a single contractor may have skewed the results of the research. By interviewing both groups the researcher was able to more accurately establish a snapshot of the perceptions of Auckland based main contractors towards BIM technologies.

Prior research examining the benefits and barriers of BIM use has collected data using postal surveys, interview surveys and case studies as presented in the table over the page.

Table 1 Data collection and analysis methods used by previous BIM studies

Author	Purpose of Research	Method of Data Collection	Data Analysis Method
McGraw Hill	Understanding, perceptions and usage patterns of BIM software	Interview, postal and online survey	Statistical Analysis and Qualitative description
Constructing Excellence NZ	Outline benefits and changes using BIM on a single project	Case Study	Qualitative description
VTT Technical Research Centre of Finland	Barriers to inter-organizational BIM use	Interview survey	Qualitative description
Tse, Wong, Wong	Interfacing and adoption barriers of BIM	Online questionnaire survey	Statistical Analysis and Qualitative description
Yan and Damian	Survey current use of BIM and barriers to greater use	Postal survey	Descriptive statistics and analysis
Azhar et al	Benefits, risks and challenges of BIM use	Online questionnaire survey, case study	Qualitative description and Statistical Analysis
Post	Resistance to BIM use	Interview survey, case study	Qualitative description

3.5 Interview schedule

The interview schedule was compiled in accordance with the guidelines set out in social research guides (listed below) and was primarily made up of open ended questions.

The guidelines dictate that the interview schedule should:

- Use non-directional wording in the question
- Only include questions that are relevant to the research question
- Be specific and unambiguous (Denscombe, 2007; Fellows & Liu, 1997; Naoum, 1998).

The interview schedule was made up primarily of open ended questions. After the participants had finished responding to the questions on the benefits and barriers of BIM technologies a checklist of those benefits and barriers discovered in the literature review was queried to ensure that no issues were simply forgotten by the participant at the time of the interview. The checklist of benefits was:

- Increased prefabrication
- More efficient communication

- Coordination
- Visualisation
- Improved programming/sequencing

The checklist of barriers was:

- Liability
- Ownership issues
- Lack of training
- Cost
- Interoperability
- Cultural issues/resistance to change

While stating the issues identified in the literature may appear to impose the researcher's bias over the interviews it was important that issues were examined in depth rather than simply investigating their frequency. By stating the documented issues the researcher enabled the interviewee to express their opinion towards them which allowed a deeper examination and comparison. This did not reduce the chance of discovering new issues (not identified in the literature) as the checklist was not divulged to the participants until they had finished answering the questions on benefits and barriers. As the vast majority of the research has not investigated the New Zealand context it was imperative that the opportunity to uncover issues that are specific to Auckland was maintained and that the participant was not overly influenced by the large body of foreign research.

The interview schedule began by querying the experience, age and position within the company of the interviewee in order to provide context to the interview. Although this may seem to breach the guidelines of the interview schedule construction stated above, being able to prove that the correct employee within the company was being interviewed was important for the validity and reliability of the results. Validity and reliability are discussed further below. The remaining questions were all open ended in order to allow the interviewee to express their opinion in the detail that is required for qualitative analysis (Fellows & Liu, 1997).

The interview schedule was not divulged to the interviewees prior to the interview. This ensured that the interview assessed their current understanding and opinions on the topic by not affording them the opportunity to research the topic prior to the interview.

Filter questions were used in order to divide the interview schedule into two groups; those currently using BIM technologies and those not currently using BIM. This allowed the remaining questions to be more specific and directly related to the experience of the contractor, adhering to the guidelines for interview schedules stated above (Denscombe, 2007). During the data analysis phase of the research this allowed the differences between the two groups to be identified and trends in the responses to be analysed. A full copy of the interview schedule is contained in Appendix B.

No sensitive information was sought in the interviews in order to give the interviewee greater freedom to express their opinions.

3.6 Sampling

The population defined in the research question is medium to large commercial main contractors in Auckland. The definition of main contractor has been limited to non-residential and non-civil commercial contractors. For the purpose of the study, the size of the main contractor was defined by turnover rather than number of employees. This was to account for the fact that some main contractors operate largely in a management role whereas others complete portions of work using their own employees.

A large contractor was defined in this research as having an annual turnover of \$150,000,000 or more and a medium contractor was defined as having between \$20,000,000 and \$149,999,999 annual turnover. As is shown in the table below in 2007 there were 12 large contractors operating in New Zealand and 108 medium contractors. It is to be noted that the below figures represent the entire construction industry (including civil and residential) and the whole of New Zealand. Statistics distinguishing the Auckland commercial construction market are not currently available (Elaine Koh, Department of Statistics, personal communication, July 7, 2010).

Table 2 Number of Enterprises in the New Zealand Construction Industry by Turnover (Statistics New Zealand, 2009)

Turnover range \$(000)	2000	2001	2002	2003	2004	2005	2006 P	2007 P
0-999	34,438	34,374	33,001	33,384	37,334	40,205	43,143	44,399
1,000-1,999	1,369	1,203	1,134	1,531	1,657	2,287	2,304	2,102
2,000-4,999	671	676	747	838	1,028	1,160	1,135	1,308
5,000-9,999	236	238	221	239	168	308	420	468
10,000-19,999	65	66	71	101	118	125	139	133
20,000-49,999	37	34	43	53	59	78	81	79
50,000-99,999	8	13	13	15	19	22	22	23
100,000-149,999	6	5	C	4	7	5	7	6
150,000+	7	7	C	7	6	9	11	12
Total	36,837	36,617	35,231	36,172	40,396	44,200	47,261	48,529

For the purpose of this research Auckland was defined as the area under control of the Auckland Regional Council in July 2010, prior to the establishment of the 'Super City'. This area includes the following city council areas: Auckland City, North Shore City, Waitakere City, Manukau City, Franklin District, Papakura District and Rodney District as shown on the map below.



Figure 3 Auckland Regional Council Boundaries (Department of Internal Affairs, n.d.)

In order for a sample to be representative of the wider population it must have the following characteristics:

- Consistent
- Unbiased
- Efficient
- Sufficient (Fellows & Liu, 1997, p. 122)

Non-random purposive sampling was used to select the sample. The researcher used a process similar to quota sampling to ensure that the appropriate number of large and medium size contractors were interviewed (Denscombe, 2007). Often utilising purposive sampling, which involves the researcher selecting the sample based on their judgment and knowledge, leads to the results being less representative if the criteria for selection is not directly stated (Burns, 1997). Bouma (2000, p. 131) states that “while large samples may seem more conclusive, it is *how* the sample is drawn that determines how representative it is.”

The selected contractors had to fulfil the following criteria:

- Operate as a main contractor in the Auckland area
- Have turnover fitting the definition of large to medium contractor (as above)
- Core business must be non-residential, non-civil building work

A sample size of seven participants working for five different construction companies was chosen. Four of the participants worked for medium sized contractors and three worked for large contractors. In the 2007 financial year the Department of Statistics reported that contractors with a turnover of over \$150,000,000 accounted for 15.8% of the income for the entire New Zealand industry. The group defined as medium contractors by this research carried out a slightly higher value of work

(approximately 17%) and hence a larger sample size was used for the research (Statistics New Zealand, 2009). Statistics for the entire New Zealand construction industry have been used, as figures relating to the Auckland industry only, were not available at the time of the sample selection (Elaine Koh, Department of Statistics, personal communication, July 7, 2010).

While at first glance it may appear that the sample of large contractors was more representative due to its proportion of the entire large contractor population, it is important to note that the research is investigating the Auckland industry as a whole. Therefore it is the value of the work carried out that defined the required size of the sample and not the number of companies operating within the defined turnover bracket.

Three of the investigated companies were currently using BIM technologies and two were not. Of the research participants, five work for companies using BIM technologies and two for companies not using BIM. This ensured that the perceptions of both groups were established while ensuring that sufficient data was collected from experienced individuals, increasing the reliability of the findings (Burns, 1997).

Using a random method of selection the chance existed that all interviewed companies were not using BIM (or vice versa) which, as described above, would skew the results of the study (Burns, 1997). Drawing on the knowledge of the researcher ensured that the sampled group contained both sets of contractors. Further to this there were more medium sized main contractors operating in the Auckland market hence the potential with random sampling is that all the selected participants would be medium contractors (or large) which would not be representative of the turnover of work carried out in Auckland (Fellows & Liu, 1997; Statistics New Zealand, 2009).

3.7 Reliability and Validity

In referring to the interview method for gathering qualitative data, Burns (1997) describes content validity as the most important aspect that must be ensured when undertaking a survey. Content validity refers to the ability of the interview to measure what it is required to in order to fulfil the requirements of the research, and can be increased through the assessment of the interview schedule by competent peers. This was done prior to the administration of the interview through presenting the interview schedule to three lecturers at Unitec in Auckland for feedback.

Further to this Burns suggests that triangulation is the best method of ensuring reliability and validity of qualitative data. Triangulation increases the validity of the research by allowing a comparison of the results with the results from different sources which have used different research methods (Burns, 1997). In addition to the triangulation of the results, the research methodology has been compared to the methods used by similar studies as presented in Table 1.

Internal validity was also ensured through undertaking the interviews at the place of work of the participants, ensuring the confidentiality of the interview and by minimising the 'interviewer effect' in which the interviewer inflicts their bias on the participant. This should ensure that the responses are meaningful (Bouma, 2000).

Reliability is “concerned with giving the same result consistently under the same conditions” (Burns, 1997, p. 293). Reliability is difficult to establish as the research focuses on individuals and hence the results may differ based on the opinions and enthusiasm of the participants. The results were also expected to be strongly affected by time, as opinions are likely to change if the use of BIM technologies increases in the Auckland construction market. By establishing the experience in the construction industry of the participants the credibility of the responses, and hence the reliability, was however improved (Bouma, 2000).

3.8 Data Analysis

There are 3 categories of approach to the analysis of qualitative data:

- Language based
- Descriptive or Interpretive
- Theory-building (Fellows & Liu, 1997)

The method used for this research was the descriptive method which “attempts to develop a coherent and comprehensive view of the subject material from the perspective of those who are being researched” (Fellows & Liu, 1997, p. 79).

It was expected that there would be differences between the data collected in the study and the findings of the literature review, as the data collected in the literature review was primarily sourced from the United States and Europe with only a small amount available directly addressing the New Zealand context. Triangulation of the data between the primary research and the secondary data was used to establish whether or not the use of BIM technologies by contractors in Auckland is subject to the same benefits and barriers as overseas and also establish which barriers and benefits identified by the contractors were real and which were perceived. Further to this, the research established the current level of understanding of Building Information Modelling held by the sampled group of contractors.

The data collected was coded into underlying themes in order to reduce the responses into broad themes that could be easily presented. The data established under each theme was then tabulated and assessed against the findings of the literature review (Naoum, 1998).

3.9 Ethics and Confidentiality

It is important that the participants were ensured of their confidentiality in the interview in order to not bias the results. Also for ideas to develop and interviewees to express their true opinions there is the need for them to trust the researcher (Denscombe, 2007). The researcher attempted to gain this trust by completing ethics and confidentiality statements and presenting these to the interviewee before beginning the interview and anonymising the interview transcripts.

3.10 Summary

This chapter has presented the methodology used to collect data establishing the benefits and barriers of BIM technologies to medium to large main contractors in Auckland. Seven semi-structured interviews were undertaken utilising an interview

schedule with a checklist to ensure that the discovery of new issues was allowed without the chance that issues identified in the literature are present but not discussed.

Non-random purposive sampling was used to select the sample as this provided the greatest opportunity to examine a wide range of perspectives of BIM. Technically proficient users as well as senior managers were interviewed and representatives of both companies using BIM and those not using BIM were surveyed. Triangulation was used to improve the validity and reliability of the findings.

4 RESULTS

4.1 Introduction

This chapter presents the data collected from seven semi structured interviews conducted with employees of construction contractors operating in Auckland. The interviews were designed to establish the participants' perceptions of the benefits and barriers to medium to large contractors in Auckland adopting BIM technologies.

The participants of the Auckland survey were made aware of the nature of the research via a 'Participant Information Form' sent electronically prior to the interview. The information sheet stated the nature and reason for the research (including the research question) but did not contain a copy of the interview schedule. The participants were not given a copy of the interview schedule in order to limit the influence of the interviewer over the knowledge and perceptions of the interviewees, who may otherwise have been prompted to conduct research based around the interview schedule. With the permission of the participants the interviews were all recorded and field notes were taken to assess non-verbal communication. Transcripts of the interviews are contained in Appendix C. Questions 3 and 4 which asked what the benefits (3) and barriers (4) of utilising BIM were followed by a checklist of benefits and barriers identified in the literature review to ensure that the participants had not simply forgotten an issue at the time of the interview.

Interviews 1, 3, 4, 5 and 7 were all held in meeting rooms at the head office of the participant's company. Interview 2 was held in the site office of the project that the participant was currently working on and interview 6 was held in a site meeting room of the project the researcher is currently working on. As is noted in the previous chapter the location of interviews is important to maintain the internal validity of the study (Burns, 1997).

4.2 Participant characteristics

The requests for interviews achieved a 100% response rate.

All of the seven participants interviewed for the research were male. Their ages varied from 27 to 47 years old with four of the seven participants aged between 40 and 49. The seven participants worked for five different medium to large commercial main contractors operating in Auckland with their roles varying from sustainability manager to operations manager. All participants work in Auckland in roles where they would either be aware of the company's use of BIM technologies or working on projects where BIM was being used to some extent. Four of the participants are defined as senior managers and three as technical workers. The sustainability manager for company E was responsible for overseeing BIM across the company's Auckland based projects. All participants, with the exception of Participant 2 operate in roles whereby they oversee a number of projects, rather than being site based operatives. Participant 2 is a site based services manager working on a single project that is currently using BIM technologies as a component of the services package.

Employees from two large sized contractors and three medium sized contractors were interviewed. For the purpose of this research a large contractor is defined as having annual turnover of \$150 million or more and a medium contractor is defined

as having turnover of between \$20 million and \$149,999,999. Only one of the participants had less than 10 years experience in the construction industry and four had between 20-29 years experience. The participants can therefore be categorised as experienced and currently working within the Auckland construction industry.

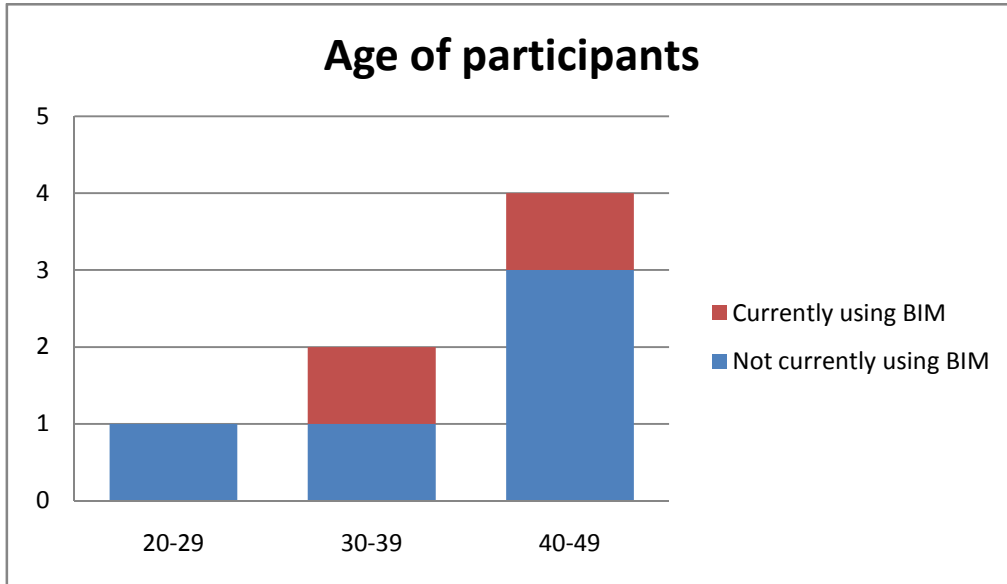


Figure 4 Age of participants

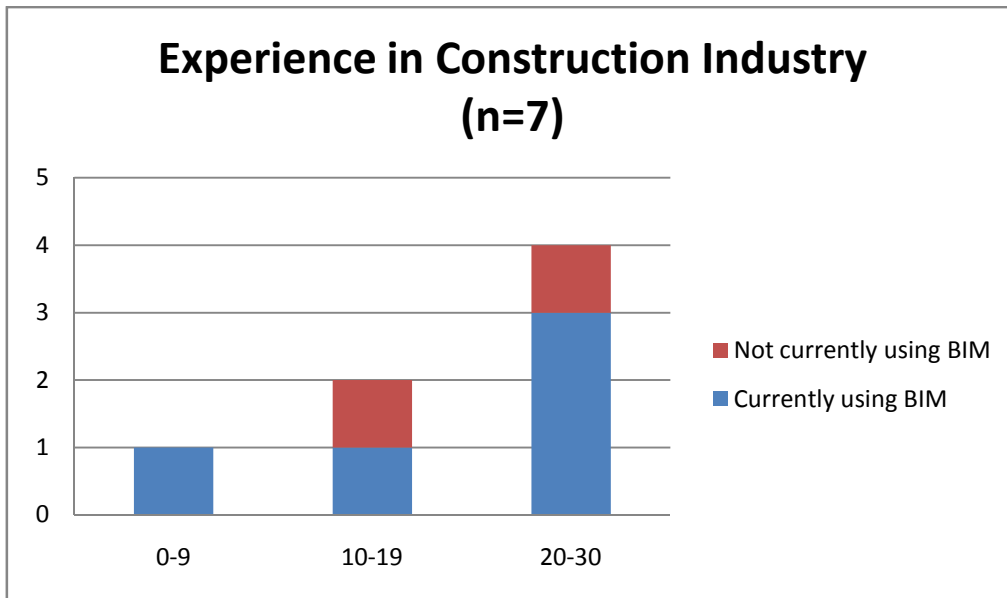


Figure 5 Participant's experience in Construction Industry

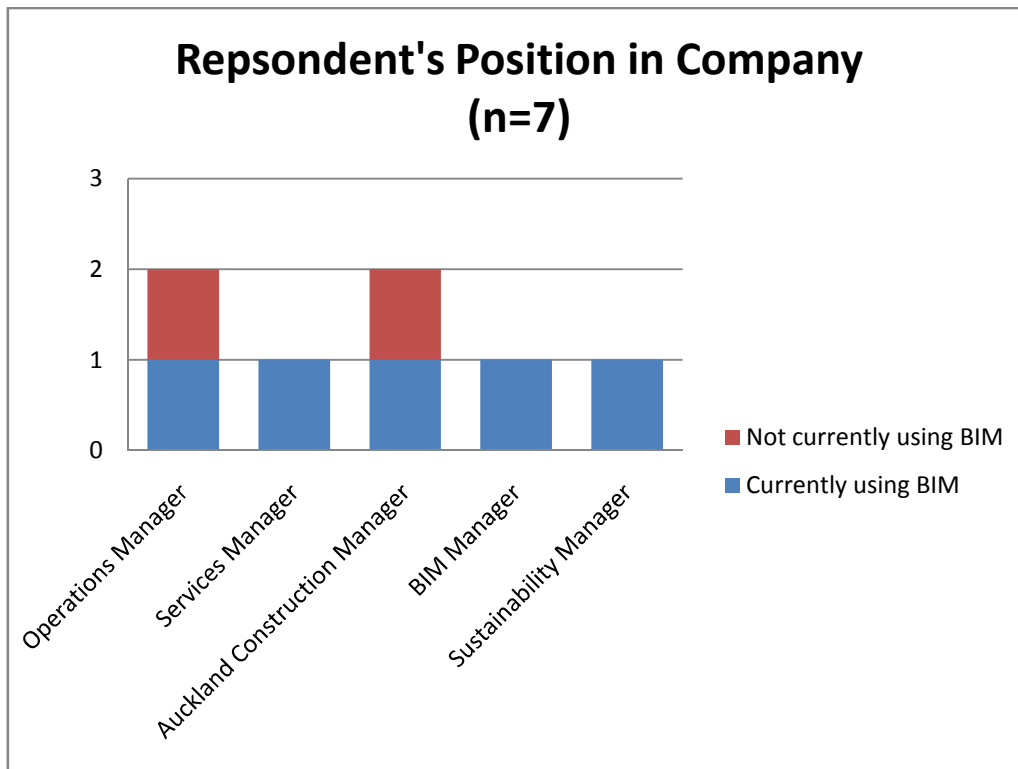


Figure 6 Respondent's Position in Company

4.3 Results

4.3.1 Definition of BIM

Of the participants employed by companies currently using BIM technologies all identified BIM as a design tool containing a greater level of information than that contained in 3D drawings. All included the 3D element of BIM in their description yet different participants specifically referred to different characteristics in defining BIM. Participant 2 specifically referred to the parametric information and spatial coordination aspects of BIM in the description, whereas Participant 1 directly identified the tagging of building components with object information. Participant 7 gave a more general definition referring to working in a “documentation space”, but through the course of the interview subsequently referred to both the parametric and object-oriented nature of BIM.

All the participants working for companies using BIM technologies, with the exception of Participant 2, referred at some stage during the interview to the relation of the model to programming or time based scheduling. Participant 2 was aware of the ability to extract bills of quantities from the model but not of the ability of BIM technologies to integrate with time based scheduling.

Only Participant 4 referred to the construction element of BIM describing it as “building something virtually before you build it in reality”. This is a more detailed view of BIM, rather than simply referring to integration with programme, as it identifies that BIM can be used to construct a building as a computer simulation. Participant 3 also referred to the ability of BIM to examine varying possible

methodologies, saying “if you built this bit of a building before that bit what would happen.”

Only one participant defined collaboration as a component of a BIM process, stating that it “draws together the idea of collaborative working and working in a documentation space that allows multiple users to input into a single model” (Participant 7). While participant 4 did not refer to integrated project delivery when defining BIM, in discussing the barriers to BIM adoption he noted that a lack of contract law concerned with collaborative working arrangements was an issue, implying that collaboration is inherent within a BIM process. He also stated that a further barrier to greater adoption was that “collaboration requires more than just here’s my price, here’s your drawings”.

Other participants linked collaboration to BIM but did not refer to collaboration as a characteristic of BIM. Participant 2 stated that “the collaborative scheme does not work, because the files are in the order of 34 plus megabyte.” He also referred to the software programme Revit as being BIM “I call it Revit, you can call it BIM” and that “BIM is the concept but the tool or the application that creates BIM is Revit”. Neither of participating Auckland Construction Managers linked BIM with collaboration. Participant 1 noted that Company A had undertaken BIM projects under both traditional contract structures and collaborative working arrangements. As was noted in the literature review it is important to establish the participants’ opinion of the relationship between BIM and collaboration as some of the barriers and benefits identified are related to IPD and not BIM.

One participant working for a company not using BIM referred to “3D modelling” but made no reference to either the nature of the information or level of detail contained within the model stating “...I haven’t had a lot of exposure to it and it’s been fragmented...” The other participant had no concept of the meaning of BIM and had not encountered the technology before answering that “I’ve got no preconceived views on it.”

4.3.2 Use of BIM

Three of the five firms were currently using BIM technologies to some extent, although only one firm was using the technology collaboratively. The company using BIM collaboratively was only using it collaboratively on three projects. All companies using BIM were utilising modelling software but not analysis or time-based software. The modelling software was being used primarily as a 3D drawing and visualisation tool and not for programming, prefabrication, costing or, in one case, even clash detection. The level of engagement with BIM by the companies using the technologies is summarised below.

Company A: Currently using BIM authoring software for clash detection and 3D visualisation but not using a collaborative BIM process. On present projects there is no integration of the model with time or cost parameters however these have been used on previous projects. Previous projects which have used the BIM process to a greater level have been undertaken under both collaborative and traditional procurement structures/working arrangements. BIM has been used on

the company's larger value projects ranging from \$35 million up, while lower value jobs have not yet used the technologies.

Company B: BIM use is currently limited to 3D drawing whereby models have been created by consultants which are then used primarily as a visualisation tool. BIM authoring software packages are currently being used on two projects in Auckland, one of which incorporates the handover of an as-built mechanical services model as a deliverable of the project. The mechanical subcontractor on the project is updating the consultant produced model to an as-built form. The architectural, structural and services models on that job have not been overlaid for clash detection and are concept models only.

Company E: BIM authoring software is being used on a number of projects across the company however only three projects are using BIM in an open information sharing and collaborative working arrangement. The best results have been achieved using BIM in a collaborative working arrangement under a Design and Build contract where all major contract parties have input into the model. The 4D or time related capabilities are not being used on any projects as the company does not perceive the resource required to input the level of detail required for a time based model to be balanced by the benefits that it allows. BIM software is being used on both large and small value projects.

Of the two companies not currently using BIM technologies one had investigated the possibility of using it 3 years prior to the interview but had felt that the technology was, at that point in time, not suited to their operation. The participant believed that the company would begin to use BIM technologies in the future and intimated that they would be investigating BIM again in the near future. The other participant working for a company not currently using BIM technologies was unaware of the technology and had no preconception of its capabilities or the issues surrounding its use.

4.4 Benefits

Question 5 of the interview asked the participants what benefits adopting BIM technologies offered construction contractors. The question included a checklist of benefits uncovered in the literature review to ensure that participants had not forgotten benefits during the interview but believed them to exist. Items from the checklist were not read to the interviewees until they had finished responding to the direct question and could not identify any further benefits. The benefits listed in the checklist were:

- Increased prefabrication
- Better/more accurate programming and scheduling
- Quicker/more efficient communication
- Increased visualisation
- Better coordination (including clash detection)

Benefits associated with quantity surveying, such as costing and creation of bills of quantities, were not included in the checklist as the research is centrally focussed on construction management issues associated with BIM.

The benefits listed by companies using BIM technologies are more reliable than those not using the technology. This is because the response is based on experience rather than hearsay or theory. Potential benefits identified by the participants are still very relevant to the research however, as a belief that the benefits are achievable will influence a decision by a main contractor on whether or not to adopt BIM technologies.

A summary table and graphical representation of the stated benefits are displayed below. The results are presented in bar chart format in order to identify frequency with which a benefit occurs. The tabular format links the responses of the individual participants to specific benefits. Both the table and the graph also identify those participants working for companies currently using BIM technologies and those who are not, in order to establish trends and differences in the responses between the two groups.

Table 3 Benefits of BIM Use

Interview Number	1	2	3	4	7	5	6
Increased Visualisation	✓	✓	✓	✓	✓	✓	✓
Marketing Tool			✓				
Increased prefabrication		✓	✓	✓			
More accurate programming/ scheduling				✓			
Better Coordination	✓	✓	✓	✓	✓	✓	
More efficient communication	✓		✓	✓	✓		

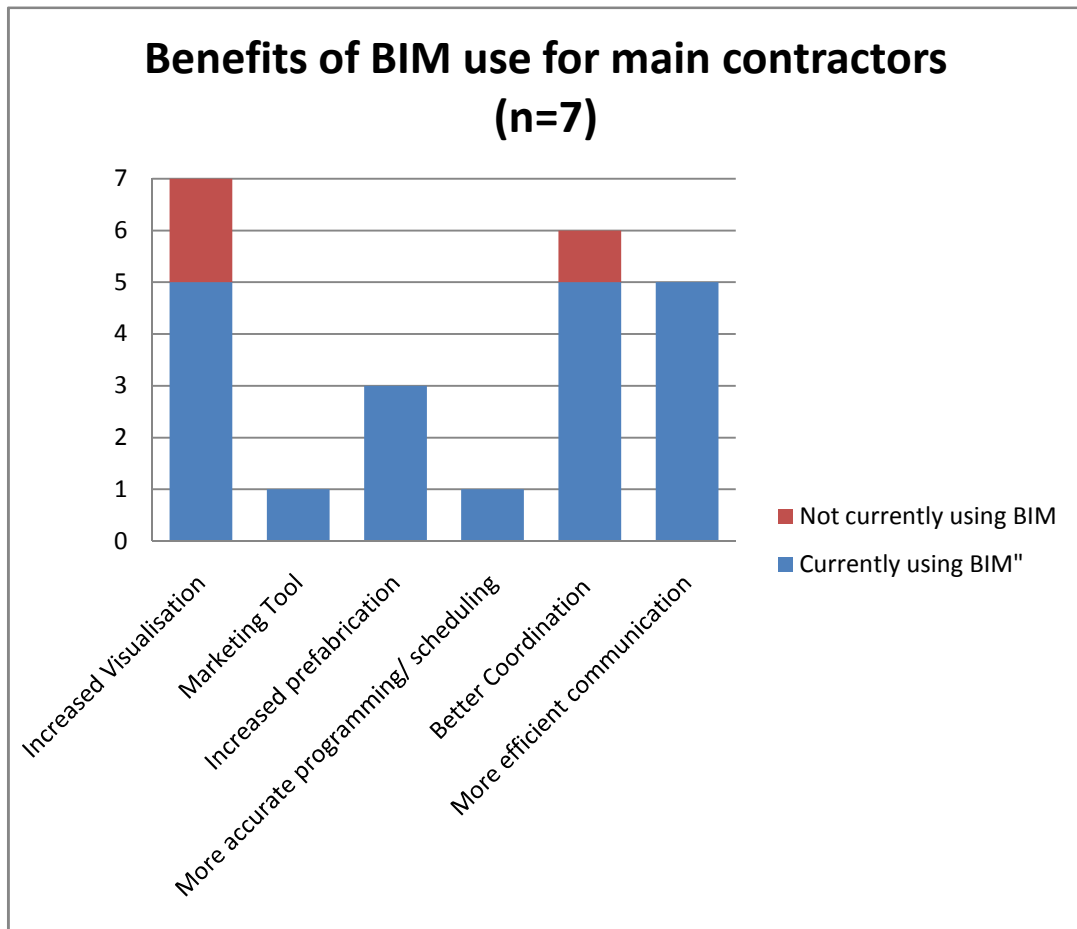


Figure 7 Benefits of BIM use for Main Contractors

4.4.1 Visualisation

As can be seen in the above table and graph the only benefit identified by all participants is the increased level of visualisation that BIM's 3D element allows. Visualisation was the only benefit identified by Participant 6 who was unfamiliar with the concept of BIM but was familiar with 3D drawings and the increased visualisation and interrogation of building connections that they afford. "Things seemed to drop in place for our guys on site, things dropped into place for me." Participant 5, also not currently using BIM, perceived that the increased visualisation that 3 dimensional details enable, would be "extremely valuable ...[for] weather tightness detailing."

4.4.2 Marketing Tool

Participant 3 identified that BIM could be used as a marketing tool for competitive advantage over other main contractors in tendering for jobs. Through the use of a time based model the contractor could clearly communicate their methodology and capability to build a facility to a client that may not have the construction knowledge to understand the proposed methodology. "[W]here you are trying to procure projects explaining your project programme if you like to a client...that might not understand

what you are saying when you say I'm going to build it in a specific manner." While this can be seen as a flow on benefit of visualisation it is directly related to the programming opportunities inherent in a full BIM process and hence can be seen as a benefit in itself. Participants 1 and 7 also referred to marketing benefits but identified these as benefits to the client in marketing the completed building to potential tenants rather than as a benefit to the contractor in marketing their company's abilities.

4.4.3 Prefabrication

Participant 2 was the only interviewee who had experienced an increased level of prefabrication due to the use of BIM. The mechanical services contractor on the project had "embraced [BIM] fully" and was "fabricating off-site to gain time, and time advantages, prefabrication wise, and this has happened on our job." Participants 3 and 4 both stated that an increased level of prefabrication was a theoretical benefit of using BIM but that they had not experienced it on any projects which they had worked on. Participant 3 stated that BIM "utopia" is "the ductwork man going in there getting the client's drawings...and using that to develop up his ductwork. Putting it into his CNC cutting machine, folding it up, sending it out to site off that drawing and then installing it." However his description was countered by the statement "that's utopia, we're nowhere near there."

4.4.4 More accurate programming/scheduling

Only one participant found that BIM enabled more accurate programming and scheduling. This was again Participant 3 who noted that "I think there's a bit of programming and realisation of that if you built this bit of a building before that bit what would happen." Other participants already using BIM technologies were either "not convinced" (Participant 1), unaware of the ability to coordinate the model with the construction programme (Participant 2) or felt that "we understand a programme and how it operates and we understand how to read a Gantt chart, we don't need to see it visually to know how to do that" (Participant 7). Participant 7 did however note that "from a sequencing point of view there are definitely advantages but perhaps those advantages aren't as great when compared to the cost and the time required to build up a good accurate 4D model."

4.4.5 Better Coordination

With the exception of Participant 6, who was not aware of BIM, all interviewees felt that BIM technologies allowed a greater level of coordination. This category refers to design coordination including the analysis of services, structural and architectural models for clash detection. The response from the participants that felt this was a benefit all focused primarily on clash detection. Participant 1 identified that "one of the greatest benefits that we have found is coordinating the design... and pointing out that there is a column in the middle of the stairwell." Participant 4 stated that "clash detection is huge". Participant 2, a site based services manager stated that "spatial coordination is the key for services at the moment" and Participant 7 responded that "one of the biggest benefits is good coordination of the drawings between services and structure and architecture, all those tricky interfaces and all those things that sort of look OK in 2D but when you pull the model together with shop drawings and actually start investigating the detail of it, things just don't line up."

4.4.6 More Efficient Communication

Question 5 also asked the participants if they felt that BIM offered a more efficient method of communication. This category has been distinguished from visualisation, referring to benefits that require a greater depth of knowledge of BIM technologies than their 3 dimensionality. Participant 1 referred to a system linking the Request for Information system to the building model whereby a Contract Instruction would take the form of a “3D pdf....and it would have the queries listed down in the inside..the text of the pdf. You click on that and it would take you into a 3D pdf. It was very cool.” Participant 7 had overseen projects where automatic updates of drawings were used instead of having to update multiple drawings or layers to enact any design change. Participant 3 noted that structural trades would “do 3D modelling for structural analysis...they won’t be doing two streams of work, there’ll be one stream of work which is modelling, which will actually be analysis as well.” Participant 2 noted the efficiency of information exchange due to the data assigned to elements of the building within a Building Information Model: “the pipe size for example is not indicated on the drawing but if you go to the model and click on the model then it will say what it is.” This interviewee did note however with this aspect of BIM that “it’s only as good as how it was inputted by the original guy and you find that a lot of the items there are default items which have no meaning.” The two participants not currently using BIM technologies, due to their unfamiliarity with BIM, did not note more efficient communication as a benefit.

It is worth noting that Participant 1’s (who had overseen the most BIM projects of all respondents) first response to the question of what benefits he felt BIM offered main contractors was that “the benefits are really to the client at the end of the day.” Five of the seven participants noted that an accurate Building Information Model was a major benefit to facilities management. While this extends outside the scope of the research, it is important to note this point due to the high number of respondents referring, unprompted, to this benefit.

4.5 Barriers

Question 6 asked the participants to identify barriers to commercial main contractors using BIM technologies. As with question 5, this question included a checklist of barriers discovered in the literature read to the interviewees after they had stated all the barriers they could think of. The checklist of barriers was made up of:

- Increased liability (including data input liability and design liability)
- Ownership
- Interoperability
- Cost
- Lack of training
- Cultural issues/resistance to change

Table 4 Barriers to BIM adoption

Interview Number	1	2	3	4	7	5	6
Model not for consent	✓						
Start Up cost		✓	✓		✓	✓	✓
Cost of modelling process	✓		✓			✓	
Lack of training		✓	✓		✓	✓	
Lack of Standards	✓	✓		✓			
Increased Liability	✓			✓			
Ownership	✓		✓	✓	✓		
Interoperability	✓	✓	✓	✓	✓		
Cultural issues	✓			✓	✓	✓	
Software/ hardware not capable		✓		✓			
Unaware of the technology							✓

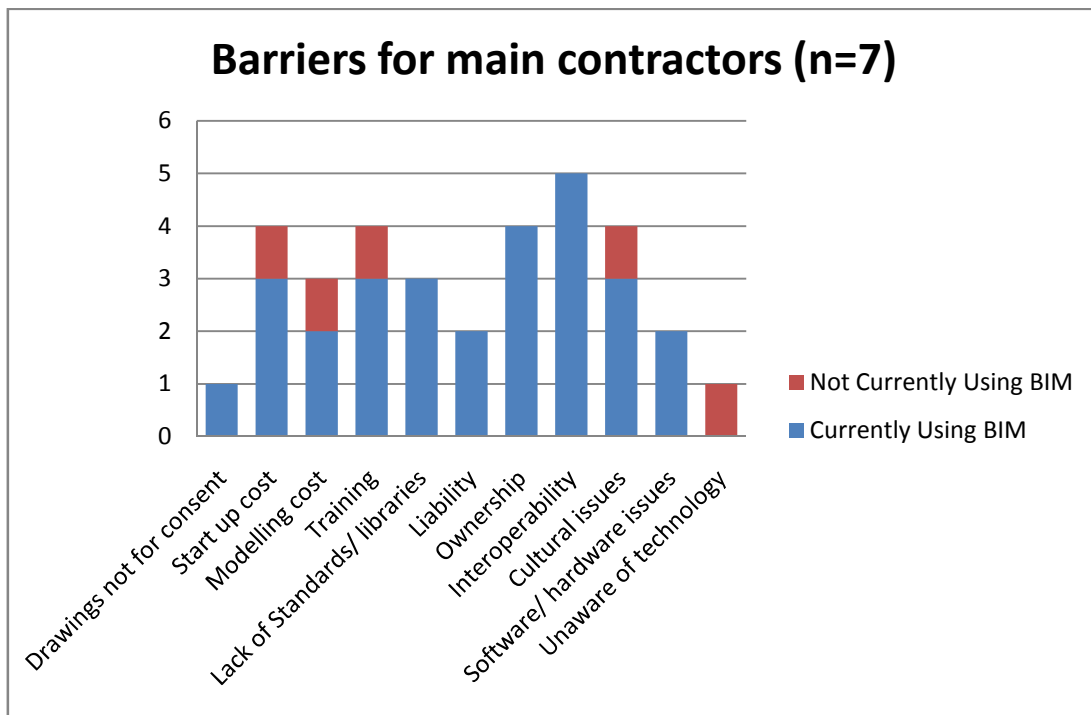


Figure 8 Barriers to BIM use for Main Contractors

No single barrier to further adoption of BIM technologies by main contractors was identified by all participants. The most frequently identified response was to the issue of interoperability with all of the 5 participants working for companies currently using BIM noting the issue.

4.5.1 Models not Accepted for Building Consent

Participant 1 was the only subject to identify that Territorial Authorities will not currently accept 3 dimensional drawings or models for consent purposes. This

participant was presently working with the North Shore City Council to attempt to change this requirement and to enable a system of “electronic transfer for building consent documents.”

4.5.2 Cost

The barrier of cost has been split into costs associated with the upgrades to hardware and software in order to use BIM technologies and the cost required to enter the increased level of design detail necessary to experience enhanced benefits from BIM.

Four of the seven participants felt that the start up cost of introducing BIM to a contractor’s operation was a barrier. Of the three participants that did not feel that start up cost was an issue, two worked for company A, which has employed BIM technologies for the longest of any of the participating firms. Participant 4 stated that initial start up cost “shouldn’t be an issue. If you’re doing a project that is potentially 60-70 million and you are going to save 10% of that, there’s your money.”

Participant 1 was less decisive in his response, noting that “it’s a bit of an issue. But it’s not, you can certainly overcome it.” This has been defined as a negative response to the barrier due to the combination of the interviewee’s body language (shrugging) and the ambiguity of the statement. Participant 5 who is not currently using BIM technologies on any projects in Auckland also did not feel that start up cost was an issue “if it’s going to ... speed up the construction time and accuracy you’d invest in it no problem at all. You wouldn’t even think twice.” Alternatively Participant 7 stated that upgrading to BIM is “a major investment” and that the cost needed to be weighed against the benefits that the technology offered; “do you make the investment in a lot of software and a lot of training for a large number of users who might only use it for a couple of hours a week.”

Participant 7 also identified the need to continually reinvest in the new versions of software programmes released annually. Participant 2 and participant 6 also referred to the “huge cost to invest” and noted “that sort of investment is massive”.

As is shown in the above table, of the four participants that felt that the start up cost was a barrier to adoption by main contractors, only two identified the cost of modelling as an issue. When asked what the barriers to greater adoption of BIM processes are Participant 1 responded “finding someone to pay for it”. Participant 6, who was unfamiliar with BIM technologies at the time of the interview, noted that the cost of modelling “probably challenges our normal tendering process we adhere to because if you have a company that is factoring in those costs and he’s competing against three other people that aren’t, I’d suggest they’re not going to have too much work.”

4.5.3 Training

A lack of training was identified as a barrier by four of the seven participants. Those who did not feel that a lack of training was an issue included Participant 6 who felt that “younger people in inverted commas coming through Unitec will be more exposed to it. They’ll be the ones who will lead it and show us old people how to use it beneficially.” In contrast Participant 5 also noted that students currently coming through the education system would have the training to drive BIM use in the industry, but still felt that a lack of training was an issue. Participant 4 stated that

“lack of training isn’t really an issue...it’s actually train as you go” due to the lack of standards for the Building Information Modelling process. One participant that believes a lack of training to be a barrier to a wider adoption of BIM technologies also felt that due to the lack of training there is a “danger... that we will start to get more drawing related people who are specialist 3D draftees rather than people with specialist knowledge in our industry...they may be lacking in some of the how to build and construct field.”

4.5.4 Lack of Standards and Libraries

The category defined above as a “lack of standards and libraries” refers to the limited availability of both industry standards defining the way in which objects within a building information model are to be labelled and organised as well as the use of object libraries. Object libraries are collections of elements that have been designed and have properties already assigned to them ready for insertion into a model. Participant 2 stated that “because the library is very limited at this point in time...to model certain elements they are using something that belongs in another library...a pipe is actually at the moment [modelled] with the ducting library.” Participant 1 referred more directly to industry standards “ensuring that the model is built correctly you know and there are some standards industry standards...So it’s just making sure that they follow that as well.” Participant 2 also confirmed this barrier “it’s cumbersome at the moment ...there are standards that are not fully developed.”

4.5.5 Liability

For the purpose of categorising the responses, liability has been defined as an increased liability to the main contractor either through the inputting of data into the model or through the increased involvement in the design process. Whereas Participant 7 felt that BIM was “probably de-risking it for us because we get the opportunity to challenge the design early”, Participant 4 responded that “New Zealand’s current contract law doesn’t really cover BIM or collaboration, it’s driven by who’s liable, we’re actually going to need people to accept, to wear that liability collectively so that definitely is an issue.” The other participants, that did not feel that increased liability was an issue, generally felt that the liability would be defined in the contract documents and utilising a BIM process would not increase the exposure of the main contractor to any liability. “I don’t see a liability. It’s no different than taking shop drawings” (Participant 2).

4.5.6 Ownership

The responses to issues surrounding the ownership of the model took many different forms. For Participant 2 ownership of the model was not an issue, as the handover of a completed as-built mechanical model formed part of the deliverables for the project he was currently completing. Participant 5 also did not feel that model ownership was a barrier stating that “you can put a price on it and sell [it].” In contrast Participant 7 noted “there are going to be challenges with ownership. We’ve already seen it a little bit on traditionally procured work where you’ve had a reluctance for people to share their model.”

Participant 4 recognised ownership as a potential barrier but felt that this could be overcome by agreeing on an industry standard detailing the process of model sharing

and ownership. “Ownership of the model is an issue, but it is only an issue because we haven’t actually...set the standard yet.” Participant 1 stated that “there is an issue there. As I’ve said when you get to the end of the project, if you continue to update it you’ve got something that is awfully valuable. I suppose that’s up to different businesses how they handle that.”

Participant 3 noted that if a contractor presented a time based model as part of a competitive tender and was unsuccessful, the potential existed for the client to pass on the methodology to the successful contractor. This indicates a loss of ownership of the intellectual property contained within the tender model.

4.5.7 Interoperability

As identified above, the most frequently noted barrier to the adoption of BIM technologies was the lack of interoperability of software programmes. This issue was noted by all participants working for companies currently using BIM. Participant 4 stated that interoperability is a “huge issue”. This was slightly countered by the statement that it was “only an issue in the design phases really” as collaboration packages could facilitate exchanges between the various software programmes. Participant 7 also noted that interoperability is “going to be an issue for everybody” and that Autodesk were “instead of developing some industry standard file formats they’re really trying just to stick to their own.” Both Participants 1 and 3 likened the lack of interoperability of software packages to “beta versus VHS” with Participant 3 further stating “we need some industry body to grab this thing and try and coordinate which is the best way forward so we don’t get the beta VHS sort of problem here where 2 people run up that path and at some point everyone who is not in one has to jump ship to the other.”

The lack of interoperability was not only identified between the products of competing software companies but also, for Revit, between the release versions of the software programme. Participant 7 noted this stating “there’s a new version of Revit every year and it changes every year so you’ve got to pay for the upgrade licence.” A completed as-built model of the mechanical services was a deliverable of the project Participant 2 was working on at the time of the interview. The limitations caused by the lack of interoperability of different generations of the software package had been addressed in the project. “This project’s been modelled in 2010... You will not be able to read a file, created in 2011, so that’s very limiting. [It] was decided, because the contractor had 2010...that will be the platform, now he’s got 2011, but we said no you’re not going to upgrade it because the client cannot afford [it].”

The two participants of companies not currently using BIM technologies were not aware of any issues surrounding interoperability.

4.5.8 Cultural Issues/Resistance to Change

The category described as Cultural Issues refers to issues involved in integrating a new process into companies with existing methods and mindsets of project delivery and includes achieving buy-in from employees. Four of the seven participants felt that this was a barrier to a greater adoption of BIM technologies. Participant 1 spoke of the “grumpy old site manager on site. 65 years old, you want him to use a

computer, I don't think so." Participant 7 also noted that cultural issues are "going to be the major one I think getting the people up to speed and getting them to buy into it and understanding that there's some value in it." Participant 3 on the other hand responded to the question "I don't see that as an issue at all...I see this as the natural evolution of CAD moving into 3D, into the BIM technology which is much more than just a drawing process."

4.5.9 Software/Hardware Issues

The item described in Table 4 and Figure 8 as software/hardware issues does not refer to the interoperability of packages but rather the ability of the available hardware and software packages to efficiently run the BIM process. Participant 4 referred to "software packages that can't handle the jandal." He also noted more specifically that "ArchiCAD cannot handle a building of that size [10 storeys]...it takes 15 minutes to load the project, I get 4 or 5 crashes every day." Participant 2 also felt that "the infrastructure is not supportive of that, really and that's a problem."

4.5.10 Lack of Awareness

As is noted above only one of the participants was not aware of BIM technologies. This was Participant 6 who stated that "the only barrier [to adopting BIM technologies was] a lack of knowledge that these systems are around."

4.6 Growth of BIM use in the Construction Industry

Questions 7 and 8 asked the participants whether or not they thought that the use of BIM technologies in the construction industry would grow in the future and if so from which group they thought that the push towards the increase would come; contractors, consultants, clients or a different group.

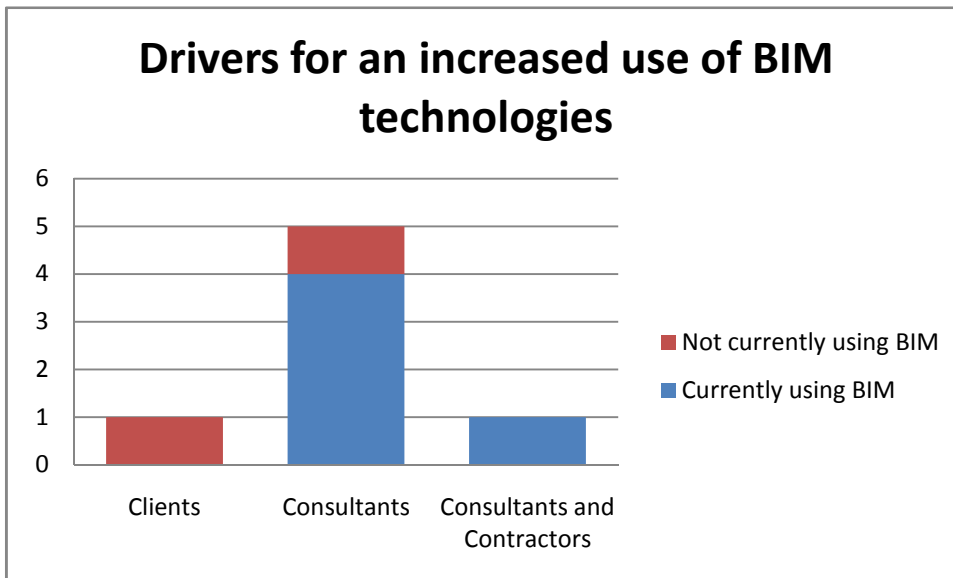


Figure 9 Drivers for an increased use of BIM technologies

All participants, including those not currently using BIM technologies, felt that BIM use in the construction industry will grow. The majority of participants believed that BIM will grow to be the preminent process used in the construction industry.

Participant 4 stated that BIM “will grow to the extent that it infuse[s] into every single part of what’s going on”. Participant 1 felt that “100% of good commercial construction will certainly be done through BIM” and Participant 3 stated that BIM was the “natural evolution of CAD”.

Participant 7 offered an alternative view of BIM uptake stating that residential construction companies “may never be interested...whereas if you get to a sort of larger commercial scale construction I think definitely there’s going to be a lot more adoption of a BIM process.” The participant also continued on to state that the frequency of uptake will be defined by the procurement models pursued in the industry “...and if we stick to a traditionally procured sort of approach where it’s hard tender and lowest cost, ignore the value...I don’t think it will be adopted to anywhere near the same degree as if we go to a more performance based contracting.”

Of the seven participants only one believed that the drive towards a greater use of BIM technologies would come from contractors, and that participant felt that the drive would not come solely from contractors but also from consultants. Five of the seven participants believed that consultants would be the group pushing for an increased use of BIM. Participant 4 provided the rationale behind this belief stating “the designers are the one that started with the software that had the capacity and I think they’re the ones that see the main benefit.” Participant 2 noted that the consultants would be the drivers “and it will depend on the complexity of the architecture and the structure.”

Participant 5 was the only participant to believe that an increased use of BIM would be driven by the client. “It’s got to come from the client because the client has the money.” Further to this participant 5 felt that within the client group it would be “government institutions that will demand it.”

4.7 Summary

This chapter has presented the results of the seven semi-structured interviews. A 100% response rate was received for the selected sample and the collected data is sufficient to answer the research question and will be analysed in the following chapter.

5 ANALYSIS

5.1 Introduction

This chapter analyses the results presented in Chapter 4. The results are interpreted and compared to the findings of the literature review. The differences and similarities between individual responses are noted and discussed.

5.2 Background

The use of building information modelling appears to be much more prevalent in the United States, United Kingdom and Europe than in New Zealand (2008), (McGraw Hill Construction, 2009)(Yan & Damian, 2008)(Howard & Björk, 2008). This is despite the many benefits that contractors in those countries have experienced through the use of BIM and the decline in productivity of the New Zealand construction industry (Building and Construction Sector Productivity Taskforce, 2009; Eastman et al., 2008).

The purpose of this research is to establish the benefits and barriers to the adoption of BIM technologies by Auckland based construction contractors, focussing on BIM's construction management applicability. The research question is:

BIM 2010: What are the benefits and barriers to the adoption of BIM technologies by medium to large commercial main contractors in Auckland?

5.3 Data

Seven semi-structured interviews were conducted with employees of five medium or large construction contractors operating in Auckland. Three of the companies were currently using BIM technologies to some extent. A questionnaire was developed in line with the findings of the literature relating to the benefits and barriers of BIM and administered in face-to-face interviews. The data obtained from the interviews is largely attitudinal. The results are analysed in the same order and groupings as presented in chapter 4.

It is important to distinguish between the responses of those participants working for companies currently using BIM technologies and those that are not as there is a difference in the depth of knowledge of the participants. Responses from participants currently using BIM are based on experience rather than solely being based on perception.

5.4 Definition of BIM

The literature review identified a range of definitions for BIM. Firstly it was established that the term BIM can be used as a verb or a noun, referring to either a building information model as an object or building information modelling as a process (buildingSMART, 2010)

Further to this the definitions of BIM varied in their scope and direction of consideration, some defining collaborative working arrangements as a characteristic of building information modelling (NBIMS, 2010). The definitions also varied depending on the group defining BIM, with architects focussing on the design applications of BIM, engineers focussing on its structural applications and so on (Aranda-Mena et al., 2009).

It was found in the literature review that inherent within a building information model is that it is object oriented and parametrically designed (Associated General Contractors of America, 2006). For the purposes of this research a building information model is defined as:

a data-rich, object oriented, intelligent and parametric digital representation of the facility, from which data and view appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility (Associated General Contractors of America, 2006, p. 3).

This definition can be seen to be specific to the perspective of a main contractor due to its focus on the delivery of the facility and is hence appropriate to this research.

The results of the interviews relating to the definition of BIM generally align with the findings of the literature review. The participants working for companies currently using BIM technologies all addressed the increased level of data available within the model due to its parametric design. While there was variation in the focus of the definition, the responses from those participants using BIM had common characteristics that could be identified and aligned with the findings of the literature. The variations within the responses further the alignment with the literature.

The literature review found that there were a number of terms that had developed alongside BIM, one of which is Virtual Design and Construction (VDC) (Aranda-Mena, et al., 2009). Only one participant directly referred to VDC, however another also noted the ability of BIM to interrogate different options of construction, the key feature of VDC.

Two of the seven participants identified collaborative working arrangements as a component of BIM. The other three participants working for companies using BIM technologies linked BIM and collaboration, but did not infer that a collaborative working arrangement was a requirement of carrying out a BIM process. These results are consistent with the findings of the literature review and show that there is an awareness amongst the respondents that Integrated Project Delivery has to be used in order to extract the maximum benefit out of a building information modelling process (VTT Technical Research Centre of Finland, 2006). Of the participants that had used BIM within their company two had worked on projects where BIM had been used in a collaborative working arrangement and were hence responding from direct experience rather than an awareness of best practice theory. This increases the reliability of the response as it is based on experience rather than opinion or theory.

One of the participants referred to BIM as Revit, a BIM authoring software application. This indicates the focus of the participant's use of BIM as being centred within the model and shows a lack of knowledge of BIM analysis tools. The participant was currently working with a building information model and was aware of the ability to integrate the model with costing (5D) but not with programme (4D). Neither application was currently being used by the company, which is likely the reason for the participant's definition.

Of the two participants working for companies not currently using BIM, one participant was aware of the 3D element of a building information model, and made reference to the possibility of integration with facilities management operation. By referring to the ongoing maintenance and operation of a facility, the participant exemplified awareness that the amount of data within a Building Information Model is greater than that of a 3D model.

The other participant had not heard of the technology. This response is surprising as the technology is being used by a number of main contractors in Auckland and it had been expected that senior management of medium sized contractors in Auckland would, while not necessarily having an in-depth knowledge, be aware of the existence of the technology. Not knowing of BIM creates a new barrier to the adoption of BIM technologies not found in the literature and will be examined further in the analysis of the barriers.

It is important to establish clearly how the participants define BIM as the differences in definition impact on the analysis of both the current use of BIM and the benefits and barriers.

5.5 Current use of BIM in Auckland

As was discussed in the literature review there is a lack of available data on the use of BIM by contractors in New Zealand. This makes a comparison between the literature and the results of the survey difficult. In 2008 however Snijders (2008) stated that the use of BIM on a construction project in Palmerston North was one of the first uses in New Zealand.

The McGraw Hill Smartmarket report in 2009 reported that half of the surveyed contractors in the United States were using BIM or BIM related tools (McGraw Hill Construction, 2009).

Three of the five surveyed companies are currently using BIM technologies on projects in Auckland. This represents 60% of the surveyed contractors; however the size of the sample limits the external validity of the results and hence limits the reliability of any comparison with the figures presented in the literature review. The frequency of BIM use in Auckland is only a sub question of the research and the limitations placed on the survey by the sample size are therefore minimal.

Despite the lack of external validity the figures suggest that use of BIM has grown since the Constructing Excellence report in 2008. The results also indicate that BIM technologies are currently being used on multiple projects in Auckland.

BIM is currently being used to a limited extent by the contractors using it in Auckland. None of the contractors were using the 4D or 5D capabilities of BIM and it was centrally being used as a clash detection and visualisation tool. This will limit the benefits directly experienced by the participants and mean that many of the benefits documented in the literature will not have been encountered.

As five of the seven participants are currently using BIM technologies the responses are however based on both experience and opinion. It is important to examine the benefits and barriers from the perspective of both companies currently using BIM and companies that are not using BIM as perception as well as experience will dictate the future growth of BIM technologies.

5.6 Benefits

The aim of the research is to evaluate the benefits and barriers of adopting BIM technologies for construction contractors in Auckland. The interview method was utilised to gather the opinions of contractors working in the Auckland construction

market in order to facilitate a comparison with the benefits and barriers that have been documented in the literature. It is expected that there would be general agreement between the Auckland contractors and the literature with minor deviations due to differences related to geographical location.

5.6.1 Visualisation

An increase in visualisation is perhaps the most obvious benefit offered by BIM. The benefit was omnipresent in the literature and in line with this all participants identified an increase in visualisation as a benefit of using BIM technologies (Eastman et al., 2008).

Increased visualisation offers many flow-on benefits such as clearly identifying the scope of works under related trade packages, understanding of complicated connection details and a reduction of rework (Associated General Contractors of America, 2006). While the participants were not queried about these flow-on benefits it can be expected that they will be encountered due to the universally agreed benefit of increased visualisation.

It is worth noting that, as with clash detection, the benefits of an increased level of visualisation can be achieved regardless of whether or not a collaborative working arrangement is used.

5.6.2 BIM as a Marketing Tool

One of the seven participants identified that a building information model could be used as a marketing tool by contractors in trying to win projects in a competitive tender. This benefit was not noted in the literature and can be attributed to a combination of the lack of prevalence of BIM in the Auckland construction market and the increased programme visualisation enabled by the 4D capabilities of BIM.

As not all construction companies are currently using BIM technologies in Auckland, presenting a building information model to a potential client offers a competitive advantage to companies using the technology over those that are not. Further to this a contractor who has a method of construction that they believe is better than those suggested by other contractors can clearly communicate their method to a client who may not otherwise understand the intricacies of the proposed methods.

5.6.3 Prefabrication

The literature review suggested that the use of BIM technologies allowed for an increase in off-site prefabrication due to the greater level of detail in the model (Eastman et al., 2008). Interestingly only three of the seven participants felt that an increased level of prefabrication was a benefit of using BIM technologies. Only one of these participants had actually experienced this increase, with the other two participants theorising that this benefit could be achieved but that the current use of BIM in Auckland did not allow for it.

This benefit is not being experienced frequently by contractors in Auckland largely due to the limited extent to which BIM technologies are being used on projects. While BIM authoring software is being used it is generally not to the level of accuracy required in order to be able to extract data directly from the model for fabrication purposes (Katz & Crandall, 2010). The building information models

being used on the majority of the current projects identified by the interviewees had applications as visualisation tools to show architectural intent.

The lack of guarantee over the accuracy of the model by consultants also limits the ability of subcontractors to confidently extract information from it for prefabrication purposes. The model needs to form part of the 'for construction' contract documentation in order for this benefit to be experienced (Hardin, 2009). One of the participants suggested that consultants were not currently prepared to warrant that a BIM was accurate as their insurers would not provide them with cover for the liability associated with this guarantee. This participant suggested however that this issue was "starting to get worked out now".

It is hence likely that as BIM use becomes more widespread and the model takes the place of 2D 'for construction' drawings that a greater opportunity for prefabrication will increase.

5.6.4 Programming/Scheduling

BIM is inherently linked with 4D modelling in the literature. 4D modelling refers to the ability to relate the model to time, which affords an accurate assessment of site logistics, position against programme and differing methodology options (U. S. General Services Administration, 2009). This allows greater control over construction programme and scheduling and can also increase buy-in of subcontractors as proof of a chosen methodology (Fischer & Kunz, 2004).

Interestingly, only four of the seven participants were aware of BIM's 4D capabilities. Of the three who were not aware of the 4D element two worked for companies not currently using BIM. This is to be expected due to their lack of familiarity and experience with the technology and its possibilities.

Surprisingly, of the four who were aware of the ability only one felt that the programming and site logistic analyses afforded by BIM's 4D capabilities were a benefit. The other participants did not feel that the increased time and cost of inputting the level of detail into the building information model required for an accurate 4D model was equal to the benefit it achieved. This appeared to stem from a belief that the programming and scheduling of construction projects was already adequate in the industry as indicated in the response from Participant 7 "...we understand a programme and how it operates..."

The benefits that BIM affords contractors through its 4D scheduling function reported in the literature are largely taken from case studies. The benefits listed are therefore taken from experience rather than perception or theory. The responses from the Auckland survey, with the exception of Participant 1, are based on perception and not experience, as only Participant 1 had worked on a project utilising BIM's 4D functions. The benefits achieved compared to the cost and time required to enter the additional data are likely to bear a similar relation regardless of geographical location. This would suggest that the benefits are real, but due to perception the surveyed contractors are not investigating the potential.

It is worth noting that the figures presented by the New Zealand Construction Taskforce which note the decreasing productivity of the industry would appear to contrast with the belief expressed by Participant 7 (Building and Construction Sector

Productivity Taskforce, 2009). The Taskforce states that one of the reasons for the decrease in productivity is due to the lack of innovation over building processes. While no data was found directly comparing the timeliness of BIM delivered projects to those that use traditional design documentation methods, the use of BIM as a programming and scheduling tool is definitely an innovation of construction process and hence represents an opportunity for efficiencies to be gained. This view is supported by the National Academy of the Sciences in the United States which named BIM as one of five “opportunities for breakthrough improvements” in construction efficiency (National Academy of Sciences, 2009).

Interestingly Participant 1, who had worked on a project using 4D BIM, was “not convinced” of the benefits that the fourth dimension offered. This may be attributed to a lack of experience with the facility as most new processes and technological functions take time to develop. McGraw Hill (2009) noted that the benefits achieved from using BIM increase with experience.

5.6.5 Design Coordination

Design coordination, including clash detection is possibly the most common benefit noted in the literature. As stated by Eastman (2008) the cost and time benefits allowed by an early identification of a clash between building elements can be achieved regardless of whether or not the BIM process is being carried out under a collaborative working structure. The results of the survey of Auckland contractors aligned with the results of the literature review, with all contractors who knew of BIM having experienced or knowing of the benefit. The number of positive responses to this benefit by Auckland contractors can in part be attributed to the fact that the benefit is achievable under traditional contract and communication structures as well as with a low level of engagement with the BIM process. As was noted in chapter 4, two of the three companies currently using BIM technologies were not using it under an Integrated Project Delivery method.

5.6.6 More Efficient Communication

All the participants currently using BIM technologies noted that BIM provided a more efficient communication method, extending beyond visualisation. This aligns with the results of the literature review although it must be noted that the form the gains in communication efficiency took varied, both in the responses of the participants and the literature review.

One participant referred to the automatic updates of drawings enacting design changes, another referred to the linking of contract instructions directly to the model in responding to requests for information, another referred to the streamlining of design and analysis work and a further referred to the ability to have more information in a single location. All of these variations of communication efficiencies were noted in the literature review (Eastman, 2008).

It was identified in the literature that one of the communication benefits offered by BIM was the ability to prove compliance with territorial authority building codes (Azhar et al., 2008). As was noted by Participant 1 this is not currently a benefit experienced in New Zealand as local authorities will not accept 3D documentation for consent purposes. This aspect of communication is therefore a barrier to further

adoption as repetitive data entry is required to convert 3D documentation into 2D drawings for consent purposes (Howard & Björk, 2008). It is the researcher's opinion that this variation is due to the relative novelty and lack of use of BIM in New Zealand and that as usage increases territorial authorities will change the requirements for consent documentation. Participant 1 is currently working with an Auckland territorial authority to allow electronic submission of consent documentation.

The results of the Auckland survey suggest that a number of the benefits documented in the literature are being achieved by contractors in Auckland. However many of the benefits are not being achieved due to the lack of intensity of BIM use. The literature review also suggests that BIM must be used under a collaborative working structure in order to achieve maximum benefits (Katz & Crandall, 2010). It is apparent in the responses from Participant 7 that the low level of engagement by the Auckland contractors has negated the increase in benefits from using BIM under a collaborative working arrangement as that participant's company was not achieving more benefits from using BIM than the other surveyed companies operating under traditional structures.

Also to be noted is that while the participants believe that some of the documented benefits are achievable, current use of BIM in Auckland means that they are not being experienced. These benefits are therefore theoretical and are not based on the experience of the contractors.

5.6.7 Benefits to Clients

As was noted in the results chapter, five of the seven participants referred, unprompted, to the benefits of an accurate building information model to facilities management, and the most experienced user of BIM claimed that the major benefits were to the client and not to the contractor. The literature review also revealed this issue noting that whoever maintained control over the building would receive the greatest benefit (Howard & Björk, 2008). These perceptions may be seen not as a barrier to further adoption of BIM technology but they imply a requirement on clients to pay for any increased cost associated with modelling the building.

Eastman (2008) suggests that owners and contractors will receive the greatest benefits from using BIM and it is designers that receive the least. This is interesting considering that the results of the Auckland survey indicate that the majority of contractors feel the greater use of BIM will be driven by consultants. It is also interesting that contractors did not feel that the drive would come from clients considering their belief that they receive the greatest benefits from BIM. This is discussed further in the analysis of the drive to increased BIM use.

It should be noted that in addition to the benefits the survey evaluated, BIM offers a number of efficiencies to the quantity surveying profession. These benefits are outside the scope of this research and are hence not analysed.

Also to be noted is the point made by Participant 2 that a building information model is only as useful as the information that is input into it. As has been described above, a number of the documented benefits have not yet been realised by the surveyed contractors in Auckland due to the lack of detail in the models being used. As BIM

standards and libraries become more developed the effort and human resource required to input useful data into the model will reduce and hence the usefulness of the model can be expected to increase as the level and quality of the information in the model increases.

5.7 Barriers

5.7.1 Cost

The responses to the initial cost barrier by the surveyed Auckland contractors can be divided into two groups; firstly those that focussed solely on the start up costs and secondly those that felt that the cost savings afforded by BIM balanced out the initial investment. The division in response between the two perspectives mirrors the literature. The McGraw Hill survey (2008) reported that when rating various barriers to the adoption of BIM on a Likert type scale, start up cost scored 4.7 out of 10, with 10 being “most challenging” (McGraw Hill Construction, 2008). This is similar to the results of the Auckland survey which recorded four of the seven participants as feeling that the initial investment was a barrier to the adoption of BIM.

Interestingly there does not appear to be a direct correlation between the level and intensity of BIM use and the attitude towards the start up cost. The participant currently working for the company using BIM in a collaborative structure, felt that the start up cost was a barrier, whereas the most experienced BIM user felt that the initial cost was not a major barrier. The responses from the participants working for the companies using BIM to the lowest level of its capabilities reflect that the cost benefits are not being achieved due to the limited level of use and therefore making the start up cost appear as a larger barrier.

All companies currently using BIM technologies were utilising the technology on their larger valued projects. This is a reflection on the ability to recoup the costs incurred by the investment, with larger projects offering the ability for greater cost savings to be achieved, hence limiting the financial impact of the investment.

Another cost barrier identified by the Auckland survey was the ongoing costs of using BIM. This was embodied in either the cost of inputting the increased level of data into the model for it to be useful or in the cost of renewing software licences. It was noted by three participants that the Autodesk Revit software was released annually and that data was not compatible with previous editions. This leads to an ongoing investment in order to be able to use the technology and requires agreement at the beginning of a project over which version of the software the project will be modelled in. The cost of annually upgrading software was not directly identified in the literature.

5.7.2 Training

As with cost, a lack of training was identified in many of the literature sources as a barrier to the wider adoption of BIM technologies (Beck, 2009). This barrier is largely associated with the novelty of the technology and the process. The findings of the Auckland survey indicated various opinions towards the issue. Despite the availability of courses related to BIM authoring software in Auckland one participant suggested that the only way to learn BIM was to use it in a “learn as you go” scenario (Autodesk, 2010; Bentley Systems, 2010; Graphisoft, 2009). This

participant was the most technically proficient user of BIM technologies and it is likely that the reference was in relation to BIM as a process and not technical proficiency. Training for a collaborative BIM process requires becoming familiar with a new system of project delivery and represents a cultural shift.

Unitec have begun courses teaching both Revit and ArchiCAD and it is likely that this barrier will be broken down as the students completing these courses enter the Auckland industry.

The findings of the McGraw Hill (2009) survey noted that although training was a major issue, over 50% of surveyed contractors felt that the lack of available skills had little impact over the decision to implement a BIM strategy.

Interestingly one participant of the Auckland survey also stated that associated with this barrier is the difficulty of knowing the number of staff to train. The participant pointed out that the cost incurred to train a large number of staff may not be matched by benefits if the staff members only use the software for a small number of hours per week. This issue will need to be resolved within individual companies based on the scope of their BIM implementation strategy.

Only one participant noted the point made by O'Brien (2008) that the lack of training of operatives may result in the recruitment of modellers who are proficient in modelling but are not experienced in construction. The participant correctly identified this risk which may limit the buildability analysis offered by BIM due to a lack of knowledge of New Zealand construction techniques and proficiencies. It is again likely that as prevalence of BIM use in the Auckland construction industry increases this threat will diminish as more site operatives become proficient with the software.

5.7.3 Lack of Standards and Libraries

The use of BIM related industry standards can pertain to either the way in which objects within a building information model are labelled, the way in which the data within the model is organised, the ownership of the model at each stage of development or the exchange of data between software programmes (buildingSMART, 2008).

The Construction Specifications Institute is currently developing an international object library with universal objects that can be imported into building information models (Construction Specifications Institute, 2010). The lack of object libraries was noted by one participant as leading to the use of objects that did not fit within the required library, such as pipe work being used instead of ducting. The use of wrongly labelled elements limits the usefulness of the model as the data related to the particular element will be incorrect. The McGraw Hill survey of BIM use in the United States (McGraw Hill Construction, 2009) found that contractors were primarily completing their own models, secondly were using objects created by manufacturers and that the use of universal object libraries was only the third most used method of detailing. The prevalence of object library use in modelling by Auckland contractors was not investigated as part of this study.

Another participant noted that the lack of object libraries meant that designers were spending long amounts of time modelling junctions (aligning with the results of the

McGraw Hill survey (2009)) which lead to a reluctance to share the model due to issues associated with intellectual property rights. Ownership of the model and the intellectual property within it is discussed below.

All the participants that noted the lack of standards also found that this was due to the novelty of BIM technologies and were aware of efforts to develop both standards and libraries. One of the participants was actively working with both designers and other contractors in Auckland in order to develop an industry standard for model development in New Zealand. As with the training barrier it is likely that as use of BIM increases within the industry this barrier will diminish. The participants that noted the issues of standards and libraries were those that were more directly involved with using the model which exemplifies the technical nature of the barrier.

The development of industry standards is a topic that requires further research.

5.7.4 Liability

As was discussed in the literature review, but seldom noted in the literature sources, was that many of the liability issues surrounding BIM were related to the use of integrated project delivery as opposed to the use of the technologies themselves (Katz & Crandall, 2010). The barrier was present within much of the literature however the 2009 McGraw Hill survey found that, due to changes to the framework in which BIM is used meant that many of the issues had been resolved (McGraw Hill Construction, 2009).

The results of the Auckland survey align with the results of the United States survey, which found that 64% of Architecture Engineering and Contracting firms not currently using BIM felt that liability was not an issue influencing the decision to adopt BIM (McGraw Hill Construction, 2009). In the Auckland survey only two of the seven participants identified an increase in liability to the contractor as a barrier to adoption. It is unlikely that liability was ever as large a consideration for the surveyed contractors in Auckland as it was for those in the United States as BIM appears to be used collaboratively much more frequently in the United States than in Auckland. The participant working for that company believed that the collaborative use of BIM was actually “derisking” the project for them due to their ability to influence the design and that design liability would remain with the consultants regardless of the contractors influence over it. This view is perhaps slightly naïve as there is a lack of any law in New Zealand directly related to BIM or its collaborative use, as was noted by another of the participants. While the use of BIM may limit risks associated with the construction of a facility it does not limit the liability to which the contractor may be exposed. The novelty of the technology has also meant that there has not been any clear case law developed surrounding the issue. The development of contractual addendums such as the ConsensusDOCS Addendum in the United States has yet to be undertaken in New Zealand, although the prevalence of these now within the U.S. industry provides a framework for which liability issues can be addressed (Yoders, 2008).

5.7.5 Ownership

Issues surrounding ownership of a building information model and the intellectual property within it are mentioned across the literature but are generally intertwined with the use of IPD.

The issue of ownership embodies itself in different forms. There appeared to be a commonality amongst the participant responses that at the end of a project the building information model was a very valuable object and that it could be either sold to the client or form part of the project deliverables, as was suggested in the literature by Katz and Crandall (2010). This strategy was being used on the project one of the participants was currently working on, where an as-built BIM of the mechanical services formed part of the project deliverables. This aspect of model ownership therefore does not appear to form a barrier to contractors in Auckland utilising BIM to a greater extent. If collaborative work structures begin to be used more frequently in conjunction with BIM the issue of ownership may have a greater impact in New Zealand, however this is centrally related to the use of the collaborative structure as opposed to BIM use itself.

As was identified above, one participant suggested that the amount of time spent modelling by consultants had lead to a reluctance to share the model due to the intellectual property the designer had invested. This issue was not directly identified in the literature and is likely a symptom of both the lack of libraries and the use of traditional procurement strategies. Ownership of intellectual property is fundamental to any design, and while there is the possibility of breach of copyright if a BIM model is passed through various parties in an editable form, the model can be shared and interrogated in a .pdf format which removes the ability to copy elements or connections directly out of the model (Longley, 2008).

Another issue identified by one of the participants was the potential for a contractor's methodology to be used by the client should the contractor lose a tender. This issue was not identified in the literature and is likely to be only a limited view due to the single response identifying the barrier. The presentation of construction methodology in a tender situation has the potential for the concept to be 'stolen', regardless of the medium the presentation takes. While BIM does afford a greater understanding of construction methods for inexperienced clients through enhanced visualisation, if a tenderer is presenting their methodology they should be convincing a client of the benefits of their method, which requires that the client understand the method (Eastman et al., 2008). Further to this by placing the relevant intellectual property protections over the tender model the contractor can limit the chance of concepts being stolen.

5.7.6 Interoperability

A lack of interoperability was the most frequently identified barrier in both the literature review and the Auckland survey. The 2009 McGraw Hill survey of the United States found that 8 out of 10 respondents believed interoperability was limiting the value of undertaking a BIM process (McGraw Hill Construction, 2009). This aligns with the results of the Auckland survey where all of the participants working for companies currently using BIM technologies identified interoperability

as an issue associated with adopting BIM. The interviewees not currently using BIM were not aware of the issue.

In addition to the lack of interoperability between various software programmes identified in the literature, the participants of the Auckland survey noted that the issue extended further and was even apparent in the release versions of the software programme Revit, a BIM authoring tool. This issue was not discovered in the literature but is a fundamental barrier to the wider use of BIM. The requirement to agree a version of the programme and then for all participants to purchase the programme involves not only a large cost outlay but also an increase in coordination and discussion surrounding the issue. This may mean that the software package a contractor is using influences the decision over their selection by a client, as suggested by Fortner et al. (2008).

Two of the participants noted that across different software programmes there were packages available “that can pull them all together anyway”, which contrasts the view of another participant who noted that “instead of [Autodesk] developing some industry standard file formats they’re really trying to just stick to their own.” These opposing viewpoints actually mirror the literature, with Howard and Bjoerk (2008) suggesting that IFC standards had not been widely applied by software companies and are mainly used by academics whereas Amor (2007) claims that they have received wide implementation.

5.7.7 Cultural Issues/Resistance to Change

As was noted in the literature review the issue defined as cultural change can be broken into two sections; internal cultural change and external cultural change. Internal cultural change refers to the required changes within an organisation in order for employees to buy-in to a BIM process. External cultural change refers to the collaborative use of BIM and the required change in culture within the New Zealand construction industry in order to achieve this.

The response to the question on internal cultural issues split the responses of the survey participants. Two referred to the challenge of achieving buy-in, especially from experienced site workers while another felt that there would not be a challenge as the adoption of BIM was a “natural progression” of design method. Case studies presented across the literature also note the required change in internal culture and the required acceptance from site operatives representing a barrier to successful implementation of BIM (Post, 2008b).

Interestingly the largest barrier to adoption noted in the McGraw Hill study (2008) was senior management endorsement of BIM. Of the seven participants interviewed four held positions as senior managers that would be responsible for implementation of a BIM strategy company wide. Amongst these participants all held positive views towards BIM, including the two senior managers working for companies not currently using BIM technologies. This suggests that senior management endorsement is not as large a barrier for Auckland contractors as the McGraw Hill study indicates.

In order for collaboration to be used more widely in the industry there needs to be a fundamental shift way from a cost based to a value-based evaluation system

(Building and Construction Sector Productivity Taskforce, 2009). Hardin (2009) suggests that an industry shift towards a greater use of collaboration is a larger challenge than any technological shift required to implement BIM. This view was mirrored by the two participants who defined BIM as being inherently a collaborative process. The frequency at which IPD methods are used is outside the scope of this research, however it is important to note that the use of BIM under a collaborative structure is fundamental to the achievement of the greatest benefits BIM offers (Longley, 2008).

5.7.8 Software/Hardware Issues

Two participants using BIM software programmes noted the inability of the software and hardware to adequately run the models. Both noted the length of time required to load the model and that a number of crashes occurred while working inside the model. This is a technical issue that is not mentioned in the literature and is likely to be resolved with time. The fact that the barrier was only noted by two participants suggests that it is not a major barrier to wider adoption of BIM technologies by contractors. Both of the participants noting the barrier were employed in roles that required them to directly interact with BIM technologies but were not responsible for a company-wide BIM implementation strategy.

5.7.9 Lack of Awareness

Surprisingly one of the participants of the Auckland survey had not heard of BIM. This participant identified that the only real barrier to his company adopting BIM technologies was the lack of awareness of what BIM and its capabilities are. It is important to note that while a lower level of employee may not be expected to be aware of BIM technologies and its potential, the participant, as Auckland Construction Manager, works in the role that would be responsible for implementing a BIM strategy. The lack of awareness is therefore a major barrier to greater adoption, however the rarity of the response suggests that the barrier may not be widespread. The size of the sample makes the generalisation of this barrier not appropriate and it cannot, therefore, be established whether or not this barrier is prevalent within the Auckland construction industry.

This barrier was not directly identified in the literature and will become less prevalent in the industry as BIM is used more frequently. The barrier may not have been noted in the literature due to the sample selection of researchers. It is likely that in investigating issues related to BIM the majority of the research has focussed on the experiences and perceptions of BIM users. This focus leads to a lack of acknowledgement of the issues relating to BIM for contractors not currently utilising the technologies.

5.8 Future Use of BIM and Drivers

The consensus amongst all participants of the survey is that the use of BIM technologies will increase in the Auckland construction industry to a level whereby it is the preminent process used. Only one participant placed a caveat on the statement, stating that the uptake would depend on the ability of the industry to shift to a greater use of collaborative work methods. This belief is linked to that participant's view that BIM is inherently a collaborative process.

Interestingly no participant felt that the drive towards a greater use of BIM would come from contractors alone. The most frequent response was that the drive would come from consultants. This is surprising considering Eastman's claim that designers see the least benefit from using BIM (Eastman et al., 2008). The reasons for the belief varied amongst the participants, although one participant stated that designers received the greatest benefits from BIM, the opposite of Eastman's claim. A survey in 2007 by Gilligan and Kunz (2007) also found that survey participants felt that the greatest benefits were to architects and owners, however that these two groups were the least likely to drive the use of Virtual Design and Construction on a project. The majority of respondents in the Auckland survey held the belief due to the position of consultants at the front end of the design process. This suggests that none of the surveyed contractors intends to convert 2D drawings into building information models as is frequently done by contractors in the United States (McGraw Hill Construction, 2009).

The McGraw Hill survey (2008) found that 50% of surveyed contractors felt that they were the primary driver behind the use of BIM on a project, which McGraw Hill proposed was due to the fact that many contractors in the U.S. were using BIM regardless of whether or not other project team members were using it. This is a major contrast to the results of the Auckland survey and exemplifies a fundamental difference in opinion between the contractors surveyed in Auckland and those surveyed in the United States. The reason behind the difference appears to be due to the limited intensity of use that BIM receives in Auckland. As BIM is not being used to its full potential only some of the documented benefits are being achieved by contractors. This furthers the opinion held by the contractors that the main benefits of building information modelling are to the client. As is noted in the 2009 McGraw Hill survey many contractors in the U.S. are converting 2 dimensional drawings into building information models in order to achieve time, quality and communication gains (McGraw Hill Construction, 2009). This emphasises the belief held by those contractors that the benefits of the modelling process are sufficient to invest the extra human resource required.

The participant that felt that the drive towards further adoption of BIM technologies would come from both contractors and consultants suggested that the push from contractors would be through the subcontract market. He noted that some trades had already strongly engaged with the BIM process and their level of involvement would push contractors to use BIM to greater extent. This acknowledgement indicates that the participant feels BIM does not offer main contractors the greatest benefits as it is only indirectly that contractors will drive greater BIM use.

5.9 Summary

This chapter has analysed and discussed the results of the survey of seven Auckland based medium to large commercial main contractors. The results have been compared to those discovered in the literature review and it appears that the Auckland contractors are not achieving many of the documented benefits due to the low level of engagement with the BIM process.

6 CONCLUSION

6.1 Introduction

This chapter evaluates the findings of the research paper. The conclusions from the research are drawn, the limitations of the study are discussed and topics for future research are presented.

6.2 Purpose of this Study

BIM use in Europe and especially the United States is well documented, with refereed literature available examining the benefits and barriers BIM presents main contractors in the construction industry. There is a lack of knowledge over both the prevalence of BIM use, and the benefits and barriers associated with it, related to the Auckland construction industry. The research conducted for this study is therefore exploratory as it appears that no other studies have been undertaken examining this.

The research question is:

BIM 2010: What are the benefits and barriers to the adoption of BIM technologies by medium to large commercial main contractors in Auckland?

The research interviewed employees of medium and large commercial main contractors operating in Auckland, including employees working for both companies currently using BIM technologies and companies not currently using BIM technologies. This allows a greater breadth of perspective when assessing the benefits and barriers. In addition to this both senior managers responsible for overseeing multiple construction projects and technical users of BIM technologies were interviewed to further increase the depth of the examination.

While some of the responses are based on experience and some on opinion both responses are valid as the greater use of BIM technologies in the industry will be dictated by both experience and perception. A perceived barrier therefore forms a barrier regardless of whether or not it is real and has been experienced.

6.3 Summary of the Findings

This research has established the benefits and barriers to the use of building information modelling for construction contractors in Auckland 2010. In addition to this the research has identified that use of BIM technologies appears to have increased in Auckland since 2008 and that the growth is likely to continue (Snijders, 2008).

Despite the increase in the prevalence of use BIM technologies have experienced in the Auckland construction market, the surveyed contractors exemplified a low level of engagement with the BIM process. Building information models were primarily being used for visualisation and clash detection and none of the surveyed contractors were using the more advanced applications such as 4D and 5D functions. The general attitude of the contractors towards the 4D application of BIM was that the additional time required inputting the extra data necessary to relate the model to time outweighed the potential benefits that this function offers. Only one of the contractors had used 4D analysis on any projects and he was “not convinced” of the benefits. As suggested by McGraw Hill (2008) it is likely that the benefits offered by

using 4D applications would increase with experience. The rest of the responses were based on perception and not experience but indicate that there is a general negativity towards the use of 4D BIM.

The level of engagement of the contractors has also meant that many of the benefits noted in the literature review have either not been achieved or have only been achieved to a limited extent. As the benefits noted in the literature review are based on case studies and interviews the benefits are real and not based on theory or opinion. It is hence likely that if the level of engagement with the building information modelling process by Auckland contractors increases so too will the benefits experienced by those contractors.

Benefits most frequently identified by the participants were visualisation, which was noted by all participants followed by better design coordination (with all positive responses referring to clash detection). These benefits represent lower level benefits and can be experienced without undertaking BIM collaboratively or requiring integration with more advanced analysis software.

One new benefit was discovered by the study; the use of a building information model as a marketing tool during competitive tender. This benefit was only noted by one participant and is attributable to the novelty of the technology and lack of use in the Auckland market.

Increased prefabrication due to the use of BIM had only been experienced by one of the participants. This is due to the lack of accuracy within the majority of the models currently being used by the surveyed contractors and the models not being linked to the contract documents.

The research discovered three new barriers not noted in the literature. The first new barrier is that Territorial Authorities in Auckland do not currently accept building information models for consent purposes. Building consent applications must be submitted with 2 dimensional drawings. This is likely due to the novelty of the technology and will change as BIM use becomes more prevalent in the industry.

Another new barrier discovered in the study was the lack of knowledge that the technology exists. This barrier may not have been noted in the literature due to the selection of samples. The vast majority of issues related to BIM will be discovered by examining the experiences of BIM users, meaning that the researchers of the literature may not have noted the importance of investigating the reasons behind why some construction companies are not using BIM. In order to provide a reliable snapshot of Auckland main contractors the researcher deemed it necessary to explore the attitudes of companies not using BIM as well as those that are.

The two most technically experienced users of BIM authoring software noted the inability of both software and hardware to efficiently run the models. Both referred to the long amount of time required in order to load a building information model and to frequent crashes while operating within the models.

The rest of the findings of the research generally aligned with the literature review. Interoperability was the most frequently noted barrier, and was identified by all participants working for companies currently using BIM technologies. Issues associated with ownership and liability appear to be of lower importance to the

surveyed contractors due to the lack of collaborative BIM use in Auckland. These issues are as much related to collaboration as they are to BIM, and if collaborative BIM use increases in Auckland it is likely that they will need greater attention to be resolved.

6.4 Conclusions

The literature review established that there are many benefits that can be experienced by construction contractors through building information modelling. The greatest benefits have been achieved by undertaking the process collaboratively with all levels of a project team.

It appears that in Auckland the frequency with which BIM technologies are used has increased since 2008 however the level of engagement with the possibilities the technology offers remains low. While the benefits and barriers noted by the surveyed contractors generally align with those discovered in the foreign literature, the intensity of both appears muted in direct comparison. This is due to the lower level of engagement with the BIM process by the Auckland contractors.

6.5 Limitations of this Study

A sample size of seven participants employed by five medium to large commercial main contractors was selected for the collection of data related to the research topic. The aim of the data collection was to facilitate an in-depth analysis of the perceptions of Auckland contractors towards BIM and the sample size was adequate for this purpose. In order to obtain a more complete snapshot of the Auckland market, however, a larger sample size would be required.

The lack of availability of statistics directly identifying the number of commercial construction contractors in Auckland at present limited the external validity of the study. This limitation has however not compromised the research as the collected data was adequate to enable a comprehensive analysis of the benefits and barriers to the use of BIM by construction contractors.

Time is expected to have a major effect on the perceptions of contractors towards BIM technologies. While this study has provided a snapshot of the issues related to BIM in 2010 it is likely that many of the factors discussed will have changed by the time of any further research. The factors affecting new technologies are subject to frequent change as their use becomes more prevalent and issues relating to their use are resolved.

6.6 Topics for Future Research

This study has investigated the benefits and barriers to the use of Building Information Modelling by medium to large commercial main contractors in Auckland, 2010.

The research has highlighted that there is currently a lack of industry standards and object libraries. This issue is limiting the benefits that can be achieved by utilising BIM. While attempts have been made to counter both of these issues the results of both the literature review and the Auckland survey suggest that the problems have

not yet been resolved. Future research could investigate the progress of industry standards and object libraries.

This study has focused on the benefits and barriers of BIM to the construction management profession. Research that specifically investigates the implications of BIM for the quantity surveying profession needs to be undertaken in order to provide a more complete picture of the implications of BIM use for construction contractors in Auckland.

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8 APPENDIX A- Literature Matrix

Title	Author	Relevance	Topics	Resource Type	Validity	Location
BIM: The risks you need to look out for	McGreevy	Very	The risks of BIM can be broken into 3 distinct categories: intellectual property, liability for content and relationship to contract documents.	Primary	OK	Unitec database
What is BIM?	Eastman	Very	Changes associated with taking on BIM	Primary	Good	google scholar
BIM series	GSA	Very	Difference between BIM, 3d and 4d modelling	Primary-Govt. paper	Excellent	GSA website
Building Information Modelling (BIM): Benefits, risks and challenges	Azhar, Hein, Sketo	Very	BIM definition, risks and benefits	Secondary	Excellent	google scholar
Title	Author	Relevance	Topics	Resource Type	Validity	Location
Building Information Modelling- BIM: Contractual risks are changing with technology	Thomson, Miner	Very		Primary	Very Good	google scholar
Smart market report	McGraw Hill	Very	Excellent statistics and analysis	Primary	Excellent	Online
Special Report:Are you ready for	Fortner	Very		Secondary	Excellent	google

BIM?						scholar
Successfully navigating your way through the electronically managed project	O'Brien	Good	Note that the lack of training in BIM may lead to non industry personnel bringing in computer specialists not construction experts.	Secondary	Very Good	Unitec database
Case studies of BIM adoption for precast concrete design by mid-sized structural engineering firms	Oloffsson, Lee, Eastman	Good	Discusses prefabrication related to BIM use though case studies	Primary	Very Good	google scholar
BIM and construction management	Hardin	Good	Discusses issues surrounding BIM but is very opinionated	Secondary	Excellent	Unitec Library
Title	Author	Relevance	Topics	Resource Type	Validity	Location
Building Information Demystified: Does it make business sense to	Aranda-Mena	Very	Different definitions of BIM including that different professions define BIM differently. Discusses development of term as coined by Laiserin	Primary	Excellent	Unitec database
Contractors Guide to BIM	AGC	Very	Difference between creating BIM from 2D and given by the architect		Excellent	Online
Website FAQ	NBIMS	Very		Primary	Excellent	Online
Building Team Views technological tools as best chance for change	Post	Very			Very Good	Unitec database

Building Better: GSA 3d 4d BIM	Ho, Matta	Limited	The GSA is trying to control the development of BIM. Describes that GSA controls procurement of US govt facilities		Excellent	Unitec database
Title	Author	Relevance	Topics	Resource Type	Validity	Location
BIM Handbook	Eastman	Very	All aspects		Excellent	Unitec Library
Smart market report 2009	McGraw Hill 2009	Very	Includes examination of lack of construction productivity	Primary	Excellent	Online
Build smarter faster and cheaper with BIM	Madsen		General information, benefits	Secondary	Excellent	Unitec database
BIM moves to 5D	Snijders	Very	Case study of use of BIM in Palmerston North	Primary	Very Good	Constructing Excellence website
The next generation	Longley	Good	Brief article on BIM. Not very good, but New Zealand Source	Secondary	Good	Library; Progressive Building Magazine
Title	Author	Relevance	Topics	Resource Type	Validity	Location

BIM the present of the construction industry	Katz, Crandall	Very	Notes that BIM is not a single piece of software but multiple pieces. Prefabrication contractor liability Collaboration buildability issues. Reducing RFIs can shorten construction schedules. Prefab from model allows the limiting of contractor liability as they do not have to extract details from the drawings. Links being able to extract quantities for orders quicker providing positive programme benefits. Limits data entry errors as not repeatedly extracting information from the design documents into eg green star rating programmes. Notes that there is not one single model, 1 for engineer, 1 for contractor etc, uploaded to project's file	Secondary	Excellent	University of Auckland Database
Title	Author	Relevance	Topics	Resource Type	Validity	Location

The scope and role of IT in construction	Fischer and Kunz	Good	Defines VDC and 4d modelling. P11 talks about integrated design and maximising the potential for prefabrication. P12 talks about the use of 4D modelling in sequence meetings. Conclusion talks about BIM needing to receive corporate not project funding as it was an ongoing development	Secondary	Excellent	University of Auckland Database
VDC use in 2007: Significant value, dramatic growth, and apparent business opportunity	Gilligan and Kunz	Good	Survey results of 2007 VDC use. Architects and owners likely to see greatest benefit of VDC but least likely to use/require it on their projects	Primary	Excellent	University of Auckland Database

Title	Author	Relevance	Topics	Resource Type	Validity	Location
Constructors grapple with resistance to change in field (p11)	Post	Very	BIM needs to contract docContractor has to join the early in order to receive full benefits of BIM. Site guys resistant to use of models, pair young and old to overcome this. Corporate strategy rather than technology is the inhibitor of collaboration. Hard to equate cost savings achieved by BIM as it is formed through cost avoidance.	Primary	Very Good	Unitec database
Advancing the competitiveness and efficiency of the US construction industry	Board on Infrastructure and construction environment	Good	BIM is one of 5 breakthrough strategies for improving construction efficiency. Others include increased prefabrication, which BIM allows. Document also discusses the use of collaborative working arrangements.	Primary	Excellent	Online
Title	Author	Relevance	Topics	Resource Type	Validity	Location

BIM-Experts' view on standardisation and industry deployment	Howard, Bjoerk	Very	<p>Organisation of people has been what has slowed the further development of BIMs. Talks in depth about the IFC standardisation. Design intentions maintained throughout life of the model to ensure that continuity. Promote changes to processes rather than the technology. Finland BIM use figures at 45% for including contractors.</p> <p>Widespread ignorance and little use of IFC in the industry. Not much information on the cost of setting up BIM training and the like. Group most likely to benefit most from the use of BIM are those that are responsible for the operation of the facility. Greater success in smaller countries in using the IFC's whereas in the US focus of stakeholders is on price.</p>	Primary	Excellent	Unitec Database
Title	Author	Relevance	Topics	Resource Type	Validity	Location

BIM research: New IPD document quantifies savings, show obstacles	Yoders	Limited	Defines IPD	Secondary	Good	Unitec database
Barriers to BIM	Beck	Very	Claims that a ROI for BIM investment may be as high as 4 years and also that the owners may require that quantities are remeasured despite the existence of the model in order to ensure that they are not liable for the quantities contained within the model.	Primary	Very good	Unitec Database
Report of the building and construction sector productivity task force	DBH	Good	Point 47 notes the need for a more collaborative framework to the procurement of buildings, currently transaction focussed. P6 has graph of labour productivity declining. 13.1 notes that efficiencies are gained through precast and off-site fabrication.	Primary	Excellent	Online
Title	Author	Relevance	Topics	Resource Type	Validity	Location
BIMs interorganizational use in Finland 2006	VTT	Very	Looks at collaborative BIM use and interorganisational communication	Primary	Excellent	Unitec database
BIM in 2007 are we there yet?	Amor	Very	Details of IFC use	Secondary	Excellent	University of Auckland

						Database
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9 APPENDIX B- Interview Schedule

1) What do you understand Building Information Modelling to be? What are the key components of BIM?

2) Is your company currently using BIM technologies on any projects in Auckland?

If Yes Questions 3-8; If No Skip to Question 9

3) On how many projects? What size are the projects?

4) How does the company decide which projects will be undertaken using BIM technologies?

5) What benefits has using BIM technologies presented and have these increased as experience with BIM has increased?

Has the following been a benefit:

- Increased prefabrication
- More efficient communication
- Visualisation
- Improved programming/scheduling
- Better design coordination (including clash detection)

6) What issues/barriers has the company encountered in using BIM technologies and how have these been overcome?

Has the following been a barrier:

- Issues related to ownership of the model
- Increased liability
- Lack of training
- Cost
- Cultural issues/resistance to change
- Interoperability

7) Do you believe that use of BIM technologies in the construction industry will grow in the future, if so to what extent?

8) From which group do you think that a push towards an increased use of BIM will come; Client, contractor, consultant or other?

Continued from Question 2

9) Does the company intend to use BIM technologies in the future?

10) What benefits do you think BIM offers your company?

Do you think the following will be a benefit:

- Increased prefabrication
- More efficient communication
- Visualisation
- Improved programming/scheduling
- Better design coordination (including clash detection)

11) What potential barriers/issues do you think that implementing BIM technologies will bring with it?

Do you think the following will be a barrier:

- Issues related to ownership of the model
- Increased liability
- Lack of training
- Cost
- Cultural issues/resistance to change
- Interoperability

13) Do you believe that use of BIM technologies in the construction industry will grow in the future, if so to what extent?

14) From which group do you think that a push towards an increased use of BIM will come; Client, contractor, consultant or other?

10 APPENDIX C- Interview Transcripts

Interview Id	1
Company Id	A
Date of Interview	13/07/10
Time of Interview	11:01am
Age	42
Position	Auckland Regional Manager
Length of time in construction industry	25 years

Length of time with current company	22 years
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So the first question is what do you understand Building Information Modelling to be and what are its key components? So.. BIM is 3d drawings um and where they are made up of um different bits and pieces the different components are tagged um ideally they are tagged and they've got all sorts of information in them from weights to bloody material types etc. Um so what are the different components of BIM? Um... yeah I'm not sure what you mean by that. **Um I'm not meaning so much the different software programmes I'm more looking at what you have got at because I think with some of my research some people are not going to make the link between the level of information that's in there and just think its 3 dimensional drawings.** Yeah so we've been doing all sorts of things. I better not cover my mouth or you won't hear me. Um... Right through to 6D um... so we employ a BIM guy here. **Oh OK.** Um so we're doing the drawing we've um attached it to programme and to um time um programme, time and cost yeah. We haven't done a lot of the cost thing. Um... We've also been um using it in the RFI process. **Yep.** We had quite a good relationship with ah *Blank* before her business imploded. **Yeah.** Yeah and ah she was doing that. **OK yep. Um obviously so is your company currently using BIM on any projects in Auckland.** Ah. In Auckland itself um *Project Z* um is fully modelled. **Yep.** Um but we're not using a hell of a lot of that um of that technology on that particular job. Um... **So sorry so it is modelled, so you've got the, the consultants have produced the model or you guys..** Yep the consultants have produced it. Um the same thing ah at *Project X*. **Yep.** Um we've got a BIM model that's been built by the consultants and we've got access to that and we're um in the final stages of design um of a shopping centre in *Blank (Within Auckland)*. The same thing. **Oh OK.** Um where where it's been modelled by, by our guy here. Yeah. **Yep. OK and you're just not attaching the 4D and the 5D elements to it, so the time..** No. **and the programme.** No. **So you're basically using it in a 3d um context.** Yep. **Yep. Yep. OK. Um and generally on the projects that you have used BIM with has it been used, has it been, in terms of the contractual structure, or the structure of, um, yeah the contractual structure, has it been collaborative or partnering kind of structures or has it been traditional.** Um probably both. Both, in both cases. Let me just think. Um. The 2 projects we've used it the most on we convinced the client, so it was a negotiated job to answer your question. **Yep.** Um early early contractor involvement um fast track. We convinced the client to pay 150 grand to model it. Um. I don't how that budget went. Um. We probably overspent, but we obviously get a lot of benefit out of that. **Yep.** Um. The other job we, the other main job that we did was *Project Y* in *Blank (Not within Auckland)*. **Yeah.** Um and we simply made an allowance for BIM ourselves. Um it was a tendered job that one. **Yep.** And um yeah it's certainly paying off. **And so um in terms of information sharing was it quite open on those projects or is it kind of. Like the model itself was that generally just Company A that had access to that or is it...** Umm. No everyone has access to it um most of the information sharing would come through in the RFI, as I said, so that a 3D pdf would turn up umm and it would have you know the queries listed down in the inside the..

the um the text of the pdf. **Yep.** You click on that and it would take you into a 3D pdf. **Yeah.** Yeah. It was very very cool. **Yeah it sounds cool.** Yeah. **Um. And are these projects you have had BIM on are they generally of a larger or smaller size or they just kind of any...** Generally larger. **Generally larger?** Yep. **Oh OK. Um and by large do you mean above...** Uhh. Um. Well the shopping centre that we are doing at the moment is only \$35 million. That's relatively small. **Yep.** Um. The shopping centre that we built in um *Blank (Not within Auckland)* was \$60 million and *Project N in Blank (not within Auckland)* was \$65-70 million. **Yep.** And the shopping centre we're building in *Blank (not within Auckland)* at the moment. Where that's not really full BIM its just um the guys have got access to the model and we take some dimensions off it etc. **Yeah.** That's 100 ummm and, what was the other one, can't remember now. **OK. And um the proportion of projects that you are using BIM or a model on to the ones that aren't.....?** Oh in terms of value um [whistles] well in terms of value and this unknown would be 80%. **Oh really.** Yeah but in terms of number it would only be 20%. **20% Ok yeah.** Yeah. Because of the... yeah. **Um and how does the company decide which projects will be undertaken using BIM.? Is that your decision or.....?** Yeah well it's a um well for the division that's my decision and so it it, do a bit of a risk analysis on it see how complex the project is decide whether or not you need BIM **Yeah.** Are there any other benefits, can we get the client to..to um to invest at all, um all sorts of things. **Yep. OK. And now a bit more generic. What benefits has using um BIM technologies presented? And have these increased as increased ah experience with BIM has increased?** Um so the benefits ah. Heh. The benefits are really to the client at the end of the day. Cos it. At the end of the day you have a model. **Yep.** That is of huge wealth of the owner of the building. In terms of facilities management, um but, most of them can't see that. **Yeah.** You know what I mean? I suppose now we're talking barriers. Um so that's the greatest benefit. Um you know stepping back certainly getting people that can't visualise 3 dimensions um it's a great a great tool. **Yep.** Um so a lot of our, you know clients, that aren't used to that sort of thing, it's unbelievably good for that. **Yep.** Um it's great as a sales document, again for the owner of the building if he's got to on-sell tenancies or um or, or whatever. **Yep.** Um. And yeah. Um one of the, probably one of the greatest benefits that we have found is coordinating the design, which should have been coordinated anyway. **Yep.** By the designers um yeah but coordinating the design and pointing out that there is a column in the middle of the stairwell. **Yeah yeah.** And sorting it out before you get there so its pre-planned it's a pre-planning tool. **Yep. OK. Um I've just got a list here, I just want to check if you have found that these have been benefits of using BIM.** Yep. **UM. Increased prefabrication.** Umm. Not in my experience. But that's not to say that the guys down in Wellington haven't. **Yep.** Yeah. Um it depends whether you mean by. I mean certainly you're using it an awful lot in the shop drawing process around precast panels. **Yeah.** Um so yeah and make sure they all fit together. But I mean that's unbelievably important and steelwork. **Yep. Um. More accurate or better programming. So like the accuracy of your um programmes.** Oh nah I'm not convinced. **Quicker and more efficient communication.** Yep. **I guess you've answered that with the visualisation.** Yep the RFI. **Yep. And the clash detection. You've already mentioned.** Yep definitely. **Um. So then on to what what issues or barriers has the company encountered in**

using BIM and how have these been overcome. Finding someone to pay for it. **Ha ha ha yep.** Um that's the that's the biggest one. The architect, co I mean we've been on BIM for 5 years now. **Mm hmm.** The architects are finally starting to catch up and say YEP! We'll build the model the way you want it then you have an insurance problem because, because of course contractors like us and subcontractors that come in at the bottom they really want to take the information straight off the model. **Yep.** But unless the architect is going to warrant that that BIM is correct and that you can do that then you've got a problem. **Yep.** So their insurers um then get involved and say "oh hang on that's not going to work". **Yep yep.** So that's an issue that's starting to get worked out in the industry now. Um the other key one is um ensuring that the model is built correctly you know and there are some, you probably know more about this than I do, but there are some standards industry standard, in fact they're probably worldwide industry standards um around how things should be labelled and what have you. So it's just making sure that they follow that as well. **Yep.** So that it's useable. **Um any others or..?** Um. Oh there's bloody lots. Um you know people being able to handle the technology you know. You know so grumpy old site manager on site. 65 years old you want him to use a computer, I don't think so! **Yep.** You know. Um. Um. Building um Control Authority accepting Building models for um for consenting purposes. **Yep.** Um yeah and well the list goes on but, anyway. **Um so they wouldn't accept them for consent? Gotta be 2 dimensions. Really?! Crazy.** I'm actually working with a ah woman at the moment that um she's um she's with North Shore and um she's been involved in getting electronic transfer for building consent documents. **Yep.** And I'm trying to get her to get um get them into 3D. **Yep, oh really.** Yeah. So fingers crossed. **Um so I'll just do the same thing as I did with the benefits.** Yeah. **Um. So increased liability in terms of the design liability, data input liability. Do you have experience.** Yep. Yep. **Any issues surrounding ownership of the model? Obviously if someone is updating it and putting effort into...** There there is an issue there. Um. As I've said when you get to the end of the project, if you continue to update it you've got something that is awfully valuable. Um and I suppose that's up to different businesses how they handle that. **Yep.** Yeah yeah. But it is an issue. **Um interoperability? Yep, yep. You've had that as a...** Yeah we um in terms of interfacing between different systems you mean? **Mm hm.** Yeah we there's the old argument of ArchiCAD versus um Revit um. It's a bit like the old beta versus VHS isn't it? **Yeah. Yeah.** And I don't know. I don't know if there will be one that prevails I'm not close enough to it. **Yep.** Um. But there are plenty of bits of software that can pull them all together anyway. Um. **Yep.** Yeah. So we haven't had a lot of issues around it. **Um start up cost? In terms of that I'm not talking about um for example getting the client to pay for the modelling, but for just the like..getting the software and the hardware and all the training.** **Yeah.** Um yeah um yeah we have, it's a bit of an issue. But its not, you know certainly overcome it. **Yep OK. And you already mentioned the cultural issues with the 65 year old site manager.** Yeah [laughs]. **Um do you believe that the use of BIM technologies in the construction industry will grow in the future and to what extent?** Yeah definitely and I mean I think 100% of you know good commercial construction will certainly be done through BIM. Without a doubt. And you know you will be doing BIM um the councils will accept BIM models and they'll accept them online, you know they'll just have access to it. It will all just

bloody pool into one model that's sitting there. And I, I personally think that you're going to.. *Blank* did you ever come across her? **No.** She's a um bit before her time really but um I suspect that what we are going to end up doing is that there'll be a model manager. **Yep.** Now wherever that model manager sits. They might work for the architect, they might be spate consultant. But really the architect just needs to say "Look this is what I want to do bla bla bla" maybe do some pencil sketches and the modeller then becomes the drafter. **Yeah yeah.** You know and it's the same with the engineer you know we'll put a bloody bla bla bla and he just incorporates it. **Yeah yeah.** They don't to keep drawing the damn thing, so I suspect that is where it's going to go. **Yep. OK.** Yeah. **Um and from which group do you think that the push towards an increased use of BIM will come. I'm talking about the contractors or the client or consultants or someone else.** Well contractors, I mean we've pushing a lot and but really the most obvious place for it to come from is architects. **Yep.** Yeah because they, I mean they're starting to build ah design in 3D now so provided they follow the international protocol for for um labelling then they don't have a lot more work to do until they start you know doing some of the add ons that contractors might want. Um yeah. **Yeah OK. Cool that was all I had.** Very good. **Thanks very much.** No worries at all.

Interview Id	2
Company Id	B
Date of Interview	15/07/10
Time of Interview	9:01am
Age	46
Position	Services Manager
Length of time in construction industry	23 years
Length of time with current company	7 years

So what do you understand building information modelling to be and are there key components that have to be met to be um modelling..well using BIM? OK. They key thing at the moment for us is um spatial coordination is the key for services at the moment. That's one of the main things that comes out of the Revit domain or the Revit environment. **So...so sorry to interrupt. But I'm..I'm more interested in um in defining, cos I'm interested in what people define BIM as cos I've found that when I interview people they have a different understanding of what BIM is to this guy.** Right. OK. BIM offers a lot of things obviously. And it's multidisciplinary through all the consultant ranking and the contractors as well. Because it's a huge database right, it translates nice and easily to quantity surveying, bill of materials, uh it can relate to um design as well I guess. Because it has all those, they call it parametric information you can input. **Yep.** You actually re... *Deleted for annonymity...* its actually what you are doing is ah you you are turning on its head the drafting mentality or philosophy, whereas now you are entering, by entering a database, by entering information into a database you are creating a drawing that's in that reverse order. **Yep.** Now you are drawing and then you try and add it up all the quantities later it's all built into the model. **Yep.** So that's how BIM is. Building Information Model, um? Model? Module? Building information. **Modelling. Yep. Yep.** Yeah so, so it's a database. **Yep.** A huge database. **Yep. OK.** With as many ah parameters as you want to enter into it basically. **Yeah.** So that's uh, and then it ultimately has ah, I think the primary component of ah ah that is a drawing that is is useful for all different parties. **Yep.** So that's pretty much um...**That's cool.** How I see it. **Um. The next question is; is your company currently using BIM technologies on any projects in Auckland?** Well, my

understanding is limited. BIM is actually an outcome of Revit, or a part of Revit. OK. That's how I see it. **Yep.** I don't know it any other way. So I think BIM is the concept but the tool or the application that creates BIM is Revit. **Yep.** And so we have a few, I think in *Company B*, I don't know whether you've done research with *Participant 3* but we probably have um 5, 5 users I think 6, 5, 6. And at the moment the usage of Revit is probably minimalistic I think. **Yep.** Cos there's a big learning curve, an education process. **Yep.** We've, this is the first, oh it's open now, this is the first of MEP. **Yep.** Revit. **Yep.** OK and there is other for players are more structural, structural I would say is almost essential but we're not fully utilising in my opinion the the Revit domain, we're still going back to the 3D AutoCAD domain. Because we as main contractors, we are not interrogating the quantity of schedules through the drafting process. We.. and those models are not in the circulation in true circulation or in full collaboration so we don't have they won't give us any good information for the BIM. We have traditional QS regimes which they do their own measure up in a traditional way we haven't gone into the fully automated..like **Costex and things like that.** Yeah. It's just not there yet. **Yep. Um. And so for example on this project um where you are using Revit it is not being used collaboratively as like a shared database in between the supply chain is it. It's just for Deleted for anonymity.** It's only one step. It's gone just one step which is the consultants, on the door there you've got some pictures. They've done a concept arrangement on the Revit. Ok. I call it Revit you can call it BIM. The arch.. and that's been collaborative at the concept level with the architect and probably the structural engineer. The structural engineer has had form so he has kind of done it a bit separately so it's not really a true collaborative...**So they're not actually um combined the 2....** No. There's problems in in in the interface because it's still very infant. I think it's still one of the initial you know, so the architect I understand has actually done his own model which he should, it should have been collaborative so but because the interface is not clear at the moment and down libraries and all that stuff's not there. **So there's been no overlaying of the structure and the services to check for clashes and things like that or?** There's been uh what I call, not not.. they've done some of that, but it's not fully, before they handed it to us. OK. So in the model, when we got it, there's been services going through beams etc and going through themselves so it's not been fully what they call interference checks before they handed it over because it's been so fast you know. We've actually picked up the job before they can actually start to pen it out or whatever. It's one of those things. So, so then once it's been defined as best they can anyway it's handed over to our contractor which is blank, the mechanical contractor has been contracted to to evolve that into a ah coordination roll ah a coordination roll and obviously they'll have serves their own purpose for shop drawing preparation and submission and ultimately, in this contract, as-built. So that means they have to give, bring the model up to scratch so that they can hand it over to the client. **OK so that's actually like a deliverable of the project. That they hand over a completed service model to the client at the end of the project.** That's correct. And this probably one of the first projects, in my in my experience, well this is the only one that has that element. All of the projects that I have been involved with at the moment, and prior, have not gone down this path, so this is quite a learning curve. **Yep. OK, Cool.** For everybody. **Um so do you know how the company decides which projects will be**

undertaken using BIM? I can, I can, well that's easy to guess. Because of the outlay, the capital expenditure and the expertise behind it and all that sort of stuff only the larger projects can sustain, can sustain um.. applying Revit or BIM, BIM to the um, to the project. So basically on big projects only. Because you'd have to, big projects only you'd have to have the consultants buy into it as well so you know a small project is not worth the energy. **So, so is it coming from the consultants? Because I know there are other large projects that aren't using BIM, Deleted for anonymity.** Yeah. It will only have to come from the concept and design stage before it can get fully realised down track. That's the full collaborative scheme, if it's not being introduced at the consultant level then there's no, ah, no real need for the contractors to go down that path because they'll be trying to recreate something that is outside of their scope. **Yep. Yep. OK so what benefits has using BIM, or Revit, um presented and have these also, the benefits have they increased as you've become more experienced in using Revit and BIM.** The, the benefits basically for services are um, I am biased towards services of course is um spatial coordination aspects because it gives you a 3D, a 3D portrayal of space and it does offer fly through, virtual fly through ability for all contractors because you translate it to a .dwf it's read, you can read it and that application is free on the web so every contractor can interrogate the model as it is through a virtual fly through everybody has that ability. And so we are trying to embrace that component first because often when you look at drawings, there are too many drawings to understand all the layering and the complexity of the space and how things weave through it, but being able to virtually fly through will give everybody an idea, it's not like the as-built situation, but an idea, of where things are actually intended to go or zoning and then identify the issues before it becomes a problem as well. Um so and in that, in that domain, I can show you, it can give you and offer you, the parametric data that sits behind it. But it's only as good as how it was inputted by the original guy and you find that a lot of the items there are default items which have no meaning. And because the library is very limited at this point in time they are using for example... to model certain elements they are using something that belongs to another library. You know like ah, there's a good example actually, ah, a pipe, I think pipes, is actually at the moment they are using, they are drawing a pipe with ducting I think, with the ducting library, or something like that. Weird. And when you click on that entity you know, it will tell you all the details of the item, you know the water flow rates, for whatever it is hydronic or whatever, it can tell you correctly, it can tell you it's a slower return of whatever that pipe does. It will give you an elevation and a few other things which is fantastic. So. Um and that kind of information is quite handy sometimes because some...when you look at 2D drawings from draftsmen, because that's what it's called, now it's called tracing actually, when you do AutoCAD it's called tracing now. The draftsman does not translate information from the 3D model onto a 2D drawing sometimes so the pipe size for example is not indicated on the drawing but if you go to the model and click on the model then it will say what it is. That's how we are using it at the moment. **Yep.** At that level. **OK so I guess this model hasn't been linked to programme at all? Programme as in ? Construction programme.** No. I don't believe there's any link at the moment that exists. **OK. Yeah you can do like 4D models where you put in all your temporary works so then you can actually do a time based model which shows how you are going to**

build it and so link that to your programme . Um and I guess.. has using BIM provided like a chance for more off-site fabrication in terms of ducting runs and things like that, that they can create longer runs due to the increased detail that you are talking about in the model? Yeah the mechanical contractor has embraced it fully. Right and they.. this is *Company Q* worldwide. They are trying to, in fact there are a few other mechanical contractors who are trying to establish themselves as the leader in the Revit or BIM domain and because they have invested accordingly they are, there are some benefits coming out of it. They are fabricating off-site to gain time, and time advantages, prefabrication wise and this has happened on our job.

Yep OK cool. Um and what barriers have you encountered using BIM or.. OK there's a few barriers at the moment because it's still in, I call it infancy, in some degree. First of all it's uh.. the hardware required to drive it is almost fundamental. You almost need a super computer. That's number one. Ah number two. The data libraries are not really established. Number three. The education process is not um, it's not uh, it's not established as well as in all the ranks. There will be contractors who will not afford, who cannot justify the expense. This is a huge cost to invest, I'm talking about a massive cost I reckon, to invest in it for what they do. The electrical and plumbing trades for example, I can't see how they can justify going down this path for what they do. **Yep.** So you will have players, parties out there who will have to be in a traditional domain AutoCAD or whatever, in fact getting some of them on AutoCAD is pretty hard now to be able to integrate and import information between the 2; there's a problem there. Um the collaborative scheme does not work, because the files are in the order of 34 plus megabyte, megabytes actually, one file. So full collaborative scheme has to be on a network and, and alive. But when you start to have third parties involved like the architect, the consultants and the various sub trades they can't always contribute to the model if they are on Revit with them because they can't get to the internet. Not at the moment. The infrastructure is not supportive of that, really and that's a problem. I reckon it's a good concept but it's bad... it's got logistical issues. Big companies like Leighton Holdings, Leighton or whatever, which is in Australia, I reckon they...they have everything in house, they have their own architectural team, engineering team, contracting team whatever, they are on internal network of some shape or form so that will work for them. And they will probably get some benefits out of that. But not how we operate, *Company B*, we have several contractors, subcontractors, everything is subcontracted down. **Yeah, yep OK. Um and those are the main barriers?** I thought that was enough. **Um so have you noticed that there has been any increased risk with liability, with maybe other people inputting, apart from the consultants, putting data into the model then someone else is taking the liability for the data input and also actually getting more involved in design that that's potentially increasing the design liability or is that..**I don't see a liability. It's no different than taking shop drawings, which is far worse in a 2D domain to evolve than into a construction state really, whereas I think more information is better than less and having a model is far better than interpretation of 2D drawings because 2D drawings hide a lot of errors which is sort of gleaned over. With the model you can physically see and there's no question. **OK. Um have there been any issues with ownership of the model. For example *Company Q* are spending a lot of time, um inputting the model, but then I guess it's predefined that the model is owned by the client so that's..**The

model is handed over, once it's handed over what happens, because it's not full collaboration, there are several streams happening parallel and that's not how Revit works. It's supposed to work in a single file. So..it's taken 2 streams effectively, straight away. And um... **So that wouldn't have been an issue really?** Well it is an issue. If I was the client I would be uncomfortable doing that because he will take the model back at the end of the job. As the job evolves, everybody works in parallel, the architect's would have been entering, continuously updating the model, the mechanical does not necessarily update his model every time he [the architect] updates his model. So effectively he may be out of date, so we are still reliant on 2D drawings from the architect, drawings of where the walls are for example. We don't constantly update the model. I think since we've started we have only updated the model, the Revit model from the architect only once. **Oh yeah OK.** Cos every time you have to kind of put a 40 meg file on disc and you know just the logistics of of doing that, and then we have to, there's a process you have to do to import it into the main central file and all that, the architect's model on this job is three files, one of the existing building, one of the new building and all kinds of stuff, so it's just a bit of a nuisance. But there is enough information for the contractor to work with, without getting into severe strife, the nature of our job you know nothing dramatically changes or is changing often. **Um so do you believe that the use of BIM technologies in the construction industry will grow in the future?** Oh definitely I'd say. As, as technology develops in terms of hardware, um education, I think Revit which is the BIM, they're going to go through several more steps of, of development. I think we're still seeing the infancy of it. Because it's cumbersome at the moment I think, there are standards that are not fully developed. Standards mean like, how you define a parameter that everyone can but into and understand, like AutoCAD has got layering, this has got parametric information and there's standards out there that are not fully established, like an NZ Standard or whatever. So it's still going to go through a few more years yet. There are societies out there who embrace Revit or BIM. Global networks that are having conferences from time to time whereas we are still a bit remote as a contractor or as a user of it, remote from that, but we are starting to get a bit more people talking to us like architects and stuff so we are getting a bit more versed with the topic I guess. **So when it grows do you think that the push towards using it more is going to come from contractors or clients or consultants or someone else?** It has to be driven, by my mind from the consultants. You can't do it from the middle portion or the tail end again you'd be asking contractors to model the whole building before they start shop drawings and that's not profitable. They can't do that from an economically profitability point of view. So it has to be introduced at the inception. From the concept stage before someone will see that potential to evolve that further down stream. **Yep. And do you think that the consultants will have been pushed by the client, because the clients will want to use the model or do you think that the consultants will push towards greater use of BIM because it's to their benefit or...?** I think the consultants at the moment will have, um, will be the driver of whether they use BIM or not and it will depend on the complexity of the architecture or the structure and the prefabrication that they can achieve out of a BIM as well. Because it's um...oh in fact sorry, if it's the consultants they won't worry about prefabrication, they will probably from an estimating point of view they can get a tonnage of steel for

example for the PQS, project quantity surveyor, to give them an idea of budgets. From a design point of view it has, it will suit consultants really well because everything is conceptual and modelling is far easier than providing the details behind it. The detail behind it comes from the contractors shop drawings, so I think consultants will pretty much be the drivers of it. The clients I would say.. at the end of the day the client is only interested in getting a finished product, a building. Whether they want to pay a premium for that I think is very unlikely at this stage. But for an institution like university or where they put as much money into the maintenance, because of the size of the campus, and there is some maintenance benefits, they might, they might insist on having that model, but they don't... I don't think they fully understand again they are learning what's BIM all about. At the moment they haven't got BIM, but they are asking for the model. And there is another limitation actually that you can add to your list. BIM only works on everybody being on one platform. This project's been modelled in 2010. The client will need 2010 at the end. You will not be able to read a file, ah created in 2011, so that's very limiting, I think that's a bad move by Autodesk, so this job was started out in 2009, and at time of tender, it was decided, because the contractor had 2010, it's only about 6 or 7 months ago now, he had 2010, so we decided that will be the platform, now he's got 2011, but we said no you're not going to upgrade it because the client cannot afford..you know he might have budgeted that he's going to get 2009 maybe, and all of a sudden now he has to buy 2011. You know so there's a danger there. That's a problem. Everybody has to be in sync. You can down save, that's right, you can down save a file, but you can't up save a file. And at the moment it's moving so fast that it's a marketing ploy I think by Auto desk to be releasing new revisions. **Cool that was the last question. Thanks for that.**

Interview Id	3
Company Id	B
Date of Interview	20/08/10
Time of Interview	11:59am
Age	45
Position	Auckland Construction Manager
Length of time in construction industry	23 years
Length of time with current company	21 years

So the first question is what do you understand Building Information Modelling to be ? I guess I understand it to be the next step in um tying in the shop drawing process um with design documentation um and using um 3D modelling techniques to manage that and it can extend itself to some degree of programme management or showing visually ah the construction of a project in 3D in a time related or time stepped models. **Yep. Ok um is your company currently BIM technologies on any projects in Auckland?** Um I wouldn't say full BIM but we are using the early

precursor to that in the likes of we've moved from 2D drafting to Revit drawing and are using it in limited packages, either ourselves or with subcontractors. Good example *Project 1* and the *Project 2* in terms of the mechanical um installation and central plant. **Yep. Yeah I met up with Participant 2 as part of this as well.** Right. **Yep. So to move on does the company intend to use BIM technologies more in the future?** Absolutely. I think it's the driver of the way forward and I see it being integrated through our subcontract market as well as for ourselves. **And what benefits I guess have you seen out of projects where it has been used limitedly or what benefits do you perceive will come out of an increased use of BIM?** I think what it does is allow highly complicated situations to be resolved more readily. But I guess, if you go back a step what has got to happen first is the individual sub trades have got to engage with the 3D drawing then those 3D drawings have got to get integrated together so that the models ah talk to each other and then people have got to engage with using that as the tool to coordinate ah items ie structure, architecture but more importantly I think the start to it will be through services coordination. So we've got all of the services trades working in 3D and they can push together a model that runs around, a spatial model that gives them where they can or can't penetrate structural/architectural items. I think that will be the start point. Then it's more logically going to extend into facades or highly complicated structural steel items, which we are doing now and then the more simplistic concrete structures or steel structures will take some more time to get through and I suspect those will only come once they are linked to a design package or the designers are drawing in 3D because there is a limited benefit in a construction company going away and modelling a concrete structure in 3D at this point in time. **Yeah. OK so out of that kind of the integration you've talked about but I guess you're looking at clash detection and also an element of visualisation for all the players.** Yeah I think, I think it's a couple of things and you're right, its services coordination its clash detection and just all the things that go with coordination and looking at layers. Where's the most appropriate place to um put equipment and some people are better at visualizing that in a 3D sense than in a 2D drawing sense. So there's that element to it. I think there's a bit of programming and realization of that if you built this bit of a building before that bit what would happen, some people are better in a 3D sense than just trying to visualize it on a 2 dimensional paper programme or trying to take drawings and turn them into a 2D programme. It gives you a visualisation of programme, so I think that can be important for some people. I think they're very important for client sell. And front end of building process where you are trying to procure projects explaining your project programme if you like to a client or a group of people, consultants that might not quite understand what you are saying when you say I'm going to build it in a specific manner. So it can be used at that front end. They are also a good programme check for clients at a high level very quickly without them having to drill down into the programme in a large amount of detail. But again good for structure, good for high level services, they're not going to tell whether the power points in a room are necessarily in at this point in time. I think that's quite some way away. They're also very useful I think if you drill down in to the subcontract market for fabrication purposes, and you know the early players in this, probably the earliest was the structural steel industry. Who got into 3D drawings of how to put stick elements together before the structure. Unfortunately some of the

carriers for some of the 3D packages aren't compatible with the model, and Revits or they haven't come from a Revit background which tends to be one of the ones people are running along. Um and even then I think there's still some disparity in the industry and if you go to the mechanical which is the other main carrier now for ductwork and pipe work runs whether in fact it's a I think it was a duct CAD or one of these other 3D ductwork drawing packages that compete with Revit and there just seems to be some sort of question mark which one of those 2 avenues the industry wants to pursue and while we control part of industry, the subcontract part of industry has a little bit of their own body that manages how they move forward and we need some industry body to grab this thing and try and coordinate which is the best way forward so we don't get the beta VHS sort of problem here where 2 people run up that path and at some point everyone who is not in one has to jump ship to the other. **Yep, yep. And so to kind of lead on from there, I mean that's really one of the barriers to the adoption I guess further of the technology but what other barriers or issues do you see coming?** Yeah well barriers to adoption I would have said would be um entry price. All of my experience with any 3D package is um they're expensive and an individual user if you're a small business and so small projects are going to suffer the most. If you go to the major players in the let's say the structural steel again, they're all drawing in 3D, if you went to the major players in the mechanical and it tends to be the primary coordination trades so we'll pick on them they're doing it. The sprinkler trade's getting there and they have significant coordination issues with short lengths of pipe and they need to miss things so there's big advantages. The plumbers are nowhere near it. And the electricians are part way there for primary runs and big equipment boxes, but not there for individual outlets and small pieces. The lifties don't really engage with 3D drawing yet, they're still in 2D for most of the lifts and the escalators. Internal fit-out and partition companies aren't anywhere near it um structural concrete workers are nowhere near it and the structural steel trade as I've said is heavily engaged and has had a large number of years of input from most of the players in it. Certain other specialist fit-out people are into it. Some of the joiners are now getting into drawing it because they use it as a marketing tool to sell joinery. You know if they want to fly you through their kitchen it's quite nice to have a 3D drawing of what a kitchen looks like. But other joinery as in bulk items, no they're not close to it. I think the other aspect to this that hasn't been touched on, I'm almost going back to the previous question, if you adjust here you put this answer, but I think the other people who can get a lot of value out of this is the FM and you know I mean facilities management companies of big organizations. You know if you are a university or a AUT university, if you're a school that's run by the ministry, if you have these sort of, prison, someone like that you can use it if you're smart to tag all your times when you need to change out a filter or change a pump or fit a service maintenance agreement in place to regularly apply product to a certain piece of maintenance item then a 3D drawing is very helpful for the facilities management people to say go down in to the basement follow this, look at that pump and replace that valve with one of these and it can be logged and tagged into the same piece of equipment so that it can all be inventorised in a nice little common piece of data which is a stick file essentially with everything on it. So that's utopia, we're nowhere near there. The other utopia I guess is the ductwork man going in there getting the client's drawing ie the consultants 3D

drawing and using that to develop up his ductwork, ah putting it into his CNC cutting machine folding it up sending it out to site off that drawing and then installing it and then loading that same information into the as-built so it's a seamless process from design right through to construct and handover and maintenance and the ongoing maintenance of the plant or equipment. That has a range of barriers, answering this question, around who owns the technology, the drawing, the era that might exist in that drawing even though we'd love to pretend that means there's no errors there'll still be coordination issues. The door are all moved the wrong drawing will be there. Um and there's the ownership of that and there's the IP that goes with the ownership of that. If that's someone's smart idea do you really want it shared to all because it's really a danger a consultant can grab a flash drive put it in and give it to competing contractors and give them all the step change to bring them up to speed of where other contractors in the industry are at. And then there's the FM side of that where there's do you give all of that across to facilities management. So there's quite a few barriers in there in a traditional contract sense and it almost drives a slightly different form of contract. Um if you are on a design build deliver you know like a BOOT scheme a build own operate transfer sort of scheme for some of the overseas prisons and schools and that where they you know have a full design team, build the school, run it for 20 years and then hand it back to government or a client or whoever it might be, that can be very advantageous. So a scheme like this could dovetail perfectly. Most traditional contracts though are a consultant engaged by some, a contract to construct for us and or our competitors and then a delivery mechanism at the back end there which is maintaining the building by the client. So different ownership model again. That gets a little more difficult around how you then push the information through. You need to decide very early on which, for the end state, you know that's for the FM people, if they want a Revit 3D model at the end that they're log into then you've got to put that into the contract documents that you're going to use Revit for the construction phase and then the contractor has got to go back to the designers and say I need a Revit drawing to put into my Revit construction to give FM a Revit output. Or have a mechanism for changing the input to the right output at the end, that doesn't mean you go back to square one. Otherwise we lose a lot of um the advantages because we are double doing some of the activities just because there's a different carrier in the drawing sense. **Yeah I think Participant 2 spoke about that in the meeting, because there was an issue of what year of Revit they were going to use.** Yeah it's the combination of that and it's are they going to keep up and then of course you're in a captive market in terms of cost because um Revit, which is an Autodesk yeah AutoCAD, Autodesk aligned item, um have a fairly healthy tag to keep currency. **Yeah, yep. Ok so yeah you've talked about sort of ownership and interoperability and start up cost** I think the other important aspect, just jumping around there is the again if you come back to the utopia of the model you know it's a shared bit of blank paper in the middle of the table that the services people draw on their bit, the architect draws his architectural bit, the structural draw their bit that then just flicks out to the um contractor who uses that same model to develop shop drawings from the one model makes it from that model puts it in to tat model and the client ends up with that model to run the show um the consultants aren't on board yet but they're all operating on one model. In fact what tends to happen at the moment is they all work on their own models and once a

month they get together and turn it into one model. In a coordination sense and they then flick that across to us as the contractor to develop in a way a slightly different model with our subbies because they don't want to give us a working version that they own and are responsible for. So that's where the industries at right now with it.

Um. Do you see, some of the barriers I've read about, which I just want to see if you see them as being barriers to *Company B* taking up more BIM. Sure. **A resistance to change in terms of people. Um for example, not necessarily just this example, but for example site managers and ah guys on site adapting to technology or also at a higher level.** No, no I don't see that as an issue at all. I align that to AutoCAD. Um we all used to draw on tracing paper and scratch out changes and use ink pens. Um Auto CAD took its time to jump over to the preferred mechanism and we don't do any drawings on anything but CAD now and it's just the natural evolution. I see this as the natural evolution of CAD moving into 3D, into the BIM technology which is much more than just a drawing process. **OK.** The other aspect I've ignored in all this, you'll probably pick up is the quantity surveying and measuring, and that's got quite some way. I missed that process almost deliberately again in the ideal model if it's a BOOT style project no problem because you can just pull the costing straight in off the model and get reasonable feedback. The allowances around waste and the cutting of pipe into exact lengths and that aren't well managed yet to the point where the industry is OK with just taking a measurement of a pipe. It bears little semblance to the price of the project in terms of pricing up of those elemental items. So and our procurement method, certainly in Auckland, is to subcontract out packages of work which aren't aligned to taking quantities straight off a schedule which is developed off a BIM model. So there's a bit of work to do, I know some of the quantity surveying companies are reviewing options heading down that line. *Company X* have started down a path towards that, um but it's a steady steps forward progress rather than a jump in boots and all at this point. Which is the other part to it. **Um, and what about a lack of training in operatives.** Yeah there's a limit at this point as to how many people are comfortable with it. Again I suspect it will come on stream much like the CAD. There were a limited number of good operators and now many of the traditional drafting people have changed across. Many of those traditional CAD drafting people are now becoming Revit drawers. So the danger is that we will start to get more drawing related people who are specialist 3D draftees rather than people with specialist knowledge in our industry. So it will attract people from diverse industry to delve into construction, but they may be lacking in some of the how to build and construct field. **Yep, yep. Um.** And a 3D drawing unfortunately looks very good even if it isn't right. If it's constructed to look right and it's very neat and proper, to be able to draw in a traditional drawing sense you could kind of pick the difference quite easily but it's much more difficult to detect quality of drawing in a hand drawn sense than it is in a 3D sense. **Um so the last question is from which group do you think will um kind of have the push towards an increased use of BIM. Do you think it will come from clients, or consultants or contractors or subbies or someone else?** It's an interesting question. Um and I'll answer it in a round about way. I think subcontractors to the main contractor will drive it in specialist areas like I've alluded to. I think I've addressed some of this but mechanical are already doing and are increasing to do and wanting to push the boundaries there. Because it suits them and

they get value out of it in a coordination sense. Sprinkler subtrade will do the same, structural steels already doing and pushing for pushing the boundaries for getting more and more of it. Façade a little but slower, depending on what element it is. General contractors will do it a bit of where we're forced, but increasingly for services coordination clash detection. But it will be some time before they use it for cost control and um programming logic. Although it will be used increasingly by general contractors as a marketing tool to explain to clients what there needs are and how they are going to build a building and winning work as an explanation tool a fly-by of a plant room is terrific, a fly-by of a partially finished building is terrific, clients' get it, they can spin the model around. It can be very easily manipulated to show what's available, so I think that aspect will speed it along because it's useful to clients. Um consultants are already using it and will increasingly use it most if the architectural firms are running headlong into the mine for 3D drawing and most of the structural guys I know are getting on board. Their big quantum leap is going to be integrating it into their design packages so they can use,,if they do 3D modelling for structural analysis, at the moment that's not integrated with 3D drawing process. Once they can make quantum leap I think that can go ahead and they'll see much more benefit. They won't be doing two streams of work, there'll be one stream of work which is modeling, which will actually be analysis as well. All the structural calculations around. I think there's some real benefit there. Who haven't I covered? Um client FM people will use it sparingly depending on who they are, but as they become more au fait with some of what's on offer I suspect some of the bigger players like hospitals and schools and prisons and people with a long tenure of their ownership positions will reap the benefits and go onboard. They will want certainty though that the carrier they are using, whoever that might be, has got some future proof position because there's not much point, using a generic term, a Revit drawing now and finding that it's Aquus in 3 years and it doesn't talk to Revit and their data that they've kept for 10 years on the filter changes is completely incompatible now with what they should be using from an FM inventory to manage change so they will jump head long into it once they have certainty that the system has got some go forward. And as I say general contractors will adopt it but that's through sub trades first and increasingly into their own people for coordination but it will be some time I believe before industry will adopt it across the board for all sub trades. And it will be the more mature sub trades that will jump on board the earliest. You know so the most to gain and the most P and G that will support um using the technology. You know it will be hard to see a concrete sub trade who are pouring mainly slabs and doing um the odd mezzanine level seeing much value in BIM technology at this point in time. Ah a reinforcing steel placer who typically operates off a ute and a dog and a couple of men is going to struggle with the technology. But you know as I say the mechanical sub trade, the fire protection and some of those other sub trades absolute value to them. **Cool. Thanks very much for that.**

Interview Id	4
Company Id	A
Date of Interview	19/07/10
Time of Interview	10:04am
Age	34
Position	National BIM Manager
Length of time in construction industry	10 years
Length of time with current company	8 weeks

Um OK so the first question is; What do you understand Building Information Modelling to be? Um that has actually changed quite a lot. Um especially in the last couple of weeks and that's a question I've asked a lot of other people as well. To me Building Information Modelling is basically ah virtual modelling I suppose. Ah building something virtually before you build it in reality. And that's basically what it comes down to. Now that there's many facets from scheduling bills of materials and assist in costing all the way through to clash detection etc. But also um ah if applied correctly should also then translate into building management. If you've got a good model and you can, you should be able to pass that forward rather than spending, you know, tens to hundreds of thousands of dollars getting your building surveyed. It's like well here it is. That's really important. **Cool. Um you might not know this just having started with Company A. Do you know how the company decides which projects will be undertaken using BIM?** Um. At this point ah we're, because it's really new um it's based on the designer that we have or the designer we're using but also the designers of the project. The way we see it at this point, there's no point um implementing it or trying to use BIM ah on smaller projects because there aren't the savings if we are doing it on a 5-10 million dollar then the savings theoretically will pay for people like myself. Ok so at the moment it's size based. Ideally of course once we have our systems working efficiently then even small jobs will benefit from BIM. **So are you actually doing a lot of the modelling yourself then?** Ah not but yes. **You sound like you want to get away from doing that.** Well to me building information model manager, ah I'm not a BIM a building information modeller. I'm a model manager so ideally I should be managing models. Now that again depends on the consultants that you are using, the design consultants. Um we've found a few. I'm finding that there are also a couple of packages being used and some of those really do not stand up. Um we have both Revit and ArchiCAD here. Now I'm Revit based and I've spent quite a few years learning Revit. Now we have a rather large project, well its not that large it's only 10 levels um and I've been going through and doing all the HVAC um with ArchiCAD, because it was originally modelled in ArchiCAD. ArchiCAD cannot handle a building of that size. I get..it takes 15 minutes to load the project I get 4 or 5 crashes every day. Um using their MEP tool which just does not work and makes it crash even more often um and when I call support they "oh it's you again um um don't

really know how to help.” So the tool is not designed for that, which is a bit of, bit of yeah it has issues. And that’s one of the main issues I’ve found. Revit however can handle it quite happily. **Yep OK. Um so Company A are using BIM on projects in Auckland at the moment?** Um on projects in Auckland. Ah that depends... to certain levels yes. Um ah *Project Z* definitely had some BIM attached to it. However what *Company A* has considered BIM to be is mainly pretty 3D pictures for tendering. And I’m helping to develop that into true BIM. So I’ve actually been having chats with the Q.S’s and project managers and the estimators, seeing the packages that they use, how they use them, the interoperability between what I’m using and yeah we’ve still got a long way to go. We’re also looking at potentially investing in new packages. Now I’m trying to assess what we have currently um if we’re using it to anywhere near it’s capacity and if that capacity couldn’t be skewed a little bit to do what we’re doing as opposed to.. so instead of having to learn a new package and rewrite the wheel or re-enter information we use what we’ve already got, that people know how to use. Finding ways of getting things to talk. So the role is actually slightly... is a little more technical as well which is kind of nice. **Yep, Cool. So what benefits has using BIM technologies presented and also have these increased as experience with BIM has increased?** Um. Sorry, sorry what are the benefits. Well..**For the main contractor.** For the main contractor. Ok ah. Ultimately what I see the main benefits as being is reduction of risk. I mean every tender has risk built into it and basically you want to reduce that risk, so you can reduce your costs reduce your tender so that you’re more likely to be used. Even though I think that using the cheapest quote is inherent in the issues we’re having in our industry. Um and I feel that to be offering BIM you ultimately start with a higher price, because there’s actually... you require more of your consultants and your subcontractors. Um but ultimately that will save the client money in the long term. Because there are less cock ups and there are less materials wasted, less time wasted. So the benefits.. the question was....? **What are the benefits that BIM technologies present to...**Ok the benefits are saving time, saving money, saving materials. That’s ultimately what I see as being the main benefits .**Yep. And are you seeing that it’s through the level of detail that’s contained within the model or?** That’s a tricky question and it’s a good question. Um because I’ve had a lot of conversations with people over detail level. Now 3D detail level is a bit of a double-edged sword. The more 3D detail you have on a project the harder it is to use the project. Um if you are looking at it in any viewer. The more 3D information the higher the overhead. So the way I see it you need more information attached to the 3D but not necessarily more 3D detail. So it’s not necessarily the detail level its more how that details being used. Yep and its more detail, its data detail rather than 3D detail. Yep. **Yep, yep OK.** So. Yeah. **Cool, so what I’ve got is just kind of a list of things that I’ve read about BIM that you know has presented itself as a benefit overseas. And I’ll just maybe run through those and see if you..please do. So one was increased prefabrication that’s kind of because of that level of detail.** Um we’re, we’re, oh I haven’t encountered that myself personally. And I’ve, that ultimately would be a nice goal however, it’s well, to to angles one being safety, if you can prefabricate things you are actually improving safety on site because you have less people at height doing dangerous things. However your accuracy really needs to be there. Because if you are 20 mills out with steel structure and you’ve got 20 mills out, 20 mills out, 20

mills out, pretty soon things don't work. So I'm fairly sure that that would definitely be a benefit in the long term. **OK. Um you might not know this also just from not being here that long, but more accurate programming, so the programmes you are creating for production, or for construction production.** Ah again being new I have very little experience with that but to be honest there's. I don't think we've actually been applying that kind of BIM and we're looking at a couple of software packages at the moment that will help us implement this level because again that saves time and lean construction is something that has been mentioned? **Yep.** You've come across lean before? **Yep.** It has been mentioned but I'm not sure exactly how it's been implemented or how people understand it and ultimately BIM should be able to help that. **Yep, Ok. Um Quicker and more efficient communication.** Um again. I haven't had that much experience with hands on projects however what I have suggested is that in the future there should , as there is a QS, site manager, attached to each project there should also be a BIM manager attached to each project. And that they should be the ones dealing with communication with the relevant contractors. Um. Ultimately I see that if you have an issue on-site that hasn't been um hasn't been foretold with the BIM model that instead of the installer doing a bit of work around it, which is generally what happens, that should be communicated, well ideally that should be seen by the, um by the supervisor and communicated to the project manager who talks to the BIM manager, who talks to the consultant who suggests work around to the consultant. The consultant is the one of course who's publishing the producer statement and also doing the calculations. So they have a look and go "HM ahp here's a here's a potential solution" fire it back. The BIM manager says "yes that works" or "no it doesn't" um and then it gets relayed back to the installer who does the work around it according to the person who designed it. Yep so ideally its communication, um efficient communication, yes. Because, "yeah I've got a problem this pipe's hitting a beam". As opposed to "yeah I've got pipe number xy3, hitting this beam." Yeah and then you actually figure out what's going on. **Yep cool. Um and clash detection.** Clash detection is huge. Um the reason I say clash detection is huge, you can look at different software packages, for example Navisworks, if you have the version that allows clash detection, or more so proximity clash detection, saying you're within 500mm away, um yeah the price of the software goes through the roof. Because that's what saves money and time . **Yep. Yep. Um so now the next question is what issues or barriers has the company encountered in using BIM technologies and how have these been overcome?** OK. Um the first one I highlighted is bad software pack..sorry not bad software packages. Software packages that ah can't handle the jandal. Um and the vendors will tell you it can do stuff that it can't. It's ah that's something that ah that fortunately I'm listened to by my boss. Um because vendors are great at selling to management. Yep and the problem with software packages is that you need someone to drive them. **Yeah. Yep.** Um I actually read something this morning, it was the 10 ways to cripple your BIM practice and one of them was seeing a new package, buying it and giving it to your tech, your young tech savvy crew and saying "Give this a go." So, you need a little bit more planning. That's that's one of the issues. Another major..what I saw as a major issue, that hasn't been as larger issue mainly because here we are construction consultants we're not actually a construction company as such. What I saw as being an issue was people's resistance to change. In this company, the

Auckland branch of, everyone's really happy, and very keen to get this moving,. However there is, as you trickle closer and closer down to um the people building stuff it's very difficult getting him to think in BIM, but to find consultants who will model in 3D is nigh on impossible. **Really.** I've met a couple of people through some users groups I go to who are techs for MEP companies who are actually developing the MEP side of things and will be rolling them out in a year or so. So there are some people coming up to speed and the smart ones aren't just going: "yeah we can do it" they're actually getting it ready before they do so. And this is, this is currently an issue, and some of the architectural designers I have spoken with that 's their main question. "Do you have contactors that are prepared to participate?" It's also, it's more than just being able to model in 3D. Are these people interested in....collaboration requires more than just here's my price, here's your drawings. It requires a interaction and a bit of bi-direction. And you need to be, you need to participate earlier and you need to participate for longer. Yep which ideally....which has some benefits and some ah minuses however. Yeah it's, it is difficult to find these people and as I've told quite a few people if you are prepared to do this now in 10 years time you'll have the market share, so that is a major issue. **OK. Um any others.** Any others, oh you've got a few of them written down. Um at this point not that many that have struck me yet. **Yep. I'll just do the same thing I did with the benefits.** Of course. **I've got a couple written down here. Um one's from the main contractor's perspective. Um an increased liability either through design liability or also data input liability potentially?** Yep. Ah there are. Ah again I've discussed New Zealand's current contract law doesn't really cover BIM or collaboration, it's driven by who's liable. And ultimately a BIM model doesn't, and it has, there is not individual liability everyone needs to take liability for it because there will be oversights in the first 10 years of BIM and we're actually going to need people to accept that and wear that liability collectively so that is definitely an issue. And there actually needs to be legislation changes before this can work smoothly. **Yep. OK Um ownership of the model.** Uh not necessarily a problem and I've had a discussion again with some ah some of the major architectural firms about setting a standard. I've also we've been trying to broker some deals between some of the larger groups, because they're in competition I'm trying to convince them that if we have a standard that's set then it will be what's used. So maybe we all come to the party. Set a standard and generally tweak the standard if necessary but start with a standard. **Yep.** Yeah. So um I don..and most of that standard seems to suggest that everyone has their own model um and again there are issues around software packages being used and collaboration packages, So ownership of the model is an issue but it is only an issue because we haven't actually set, ah set the standard yet. **Um interoperability.** Huge issue. Yep um. It's only an issue, in the design phases really. If you're using a collaboration package such as Vicus or Navisworks it's not such an issue because you can actually put the 3D information together. However in the early stages, and this is something I have discussed with both Graphisoft who make ArchiCAD and um and the Autodesk resellers in this country, But interoperability, basically all it is, we have a product that can do everything so we don't care, and ArchiCAD are "Look they're the big bad brother we're doing our best". Now all of ArchiCAD's attempts at interoperability, though noble, don't really facilitate ongoing change and our industry as you know is all about ongoing change.

Things change all the time so things become a huge issue to.. with cross platforms and basically the suggestion is that we need to use one package which is not going to happen either so yeah there are definitely issues around interoperability. **Yep cool.**

Um the initial start-up cost? Shouldn't be an issue. If you're doing a project that is potentially 60 70 million and you are going to save 10% of that, there's your money. **That's including all the software.** Yeah yeah. You're looking at.. well yeah your start up costs, it depends on how many people you have in your team, but if you've got a team of 5 people you're probably looking at 200 k start up. Mmm so that should be easy enough to budget into your project. We've got a small crew at the moment. But its slowly growing. Mm. **OK. Um lack of training. So in terms of people knowing how to use the packages.** Um training. Well where do you go to train in BIM? Um and there are no standards set. Basically I've had this question a lot here "So have you done this before?" well not many people on the planet have. It's a really new technology so training, lack of training, it's actually a train as you go. SO lack of training isn't really an issue it's more ah it's more a matter of choosing the right people. **Yep. OK Um and also issues with, for example not being able to get the benefits out of, that the model potentially offers because it's not part of the contract documents. For example, you can't necessarily build to the model, you have to build to the 2 dimensional drawings.** Mmm hmm. Ok um well again this, so long as... some things are necessary to implement BIM. One of them is confidence. Um now there are many different formats you can use, a format that can be output by most Autodesk product is .dwf, a secure format which you can't change, which helps. Um you., there's also some nice navigation benefits, for example if you ah select a section, it takes you to section, if you select detail it takes you to detail, so rather than having a paper set and doing this all the time you can actually contained within a document that is easy to navigate. Um if as often happens the design team have omitted a few dimensions, in theory you can actually put the dimensions on the plans and are they correct. And the dwf can only be published by packages that can't align dimensions. So that kind of thing is cool, however you need confidence in the model and you need um and the designer needs to guarantee the model and this is quite difficult. And that's part, that responsibility is definitely part of BIM. And as you mentioned before where that responsibility lies is difficult. **Yeah OK. Um you've probably answered this already. Do you believe the use of BIM technologies in the construction industry will grow in the future and if so to what extent?** Ah completely. And it will grow to the extent that it infuse into every single part of what's going on. Mmm. It's going to be huge I personally think it's going to take 20 years to actually get to the point to where it's really useful. Um until then there'll be lots of savings. There'll be lots of cock ups. I've had discussions with the few architects who have already had rather large cock ups with their idea of BIM, however these are necessary to get us to where we're going yep. And there no worse than what normally happens. I had a chat to someone at a cocktail party on the weekend suggesting that ah the statistics say that most, most major construction projects mean 100 million plus on the planet, go 40% over time 40% over budget. Yep, and that's the whole industry. Yeah, yeah. If you've got a 100 million dollar project going 40% over project. That's a lot of money. So even...the cock ups that are happening aren't as drastic as what is going on anyway. Yeah there's money to be played with and it should be used. **Yep OK. Um and from which group do you**

think that a push towards an increased use of BIM will come. From the client, the contractor, the consultant or other or all of them? Ah. I think mainly the design consultants. Ah initially. In this company, one of our directors is pushing heavily. Um but I think it's mainly.. the designers are the one that started with the software that had the capacity and I think they're the ones that see the main benefit. So they're the ones that are the main push at the moment in my opinion. However as time goes on I think you'll find anyone, anyone who has adopted it will be pushing, and I think that the last people will be the installers and the contractors, because..I'm currently going through some as built and they're using 2D AutoCAD and they're really clever the way that they've been done however if they'd done it in 3D they would have noticed that, oh yeah you say you've installed this duct and you've got an exhaust going over it, but according to what you have written there's a 25mm clash. So had they done that in a 3D package then they would have picked that up. And they've installed it so it's working and they're definitely not going through each other however now I have to go back to them and say excuse me which..well what is the case here? **Yeah which one's right.** Yeah. Oh well come there and we'll get it right. However I should, as I said before I shouldn't be modelling. I'm good at modelling, but yeah I should be really thinking big picture stuff. **Yeah, yeah. Cool that was the last question.**

Interview Id	5
Company Id	C
Date of Interview	26/07/10
Time of Interview	12:28am
Age	36
Position	Operations Manager
Length of time in construction industry	19 years
Length of time with current company	7 years

So the first question as part of the questionnaire is what do you understand Building Information Modelling to be? 3D modelling of uh, the building for design. It really.. look I haven't had a lot of exposure to it and it's been fragmented because I've, and no doubt we'll get to this under your questions, I found it didn't quite suit me so I didn't put a whole lot of time into it. And it hasn't really been pushed back at me much. Yeah. **Um. So I guess is your company currently using BIM technologies on any projects in Auckland is...** Not so much in Auckland. I believe we have 1 in the company. Which is down south. But apart from that no. Not up here. **OK. Um. So does the company intend to use BIM technologies in the future?** Yes I believe so. Our sweet spot, or if you like large portion of what we do is design and build as a design and build contractor. Probably the gestation period for those projects is quite long and we might get involved in a project, 3 years later you've built it. Like you're finished. So since BIM has been on the market sort of, haven't had a really good opportunity to chuck it at one. Because they've either been in progress or it hasn't matched like fast-track. **Yep, OK cool.** But we do intend to because we can see it heading that way especially for larger projects. **Yep. OK. Um And from the perspective.. as a main contractor what do you think, what benefits will BIM offer when you do bring it in ?** I see the benefits right now as post contract benefits. Um If you are doing a large complex building, for which under design and build you are now starting to get maintenance contracts and if you go to PPPs they're even better, more onerous, you own the thing for a matter of years and we've all been slave to how good your as-building is at the end of a project. You see this on complex buildings because services are far more complex. Ah building management the whole thing is in the ground. Prison projects at the moment, if you even design to cut services to a cell block how do get around that. You just can't do it. So to be able to accurately pin point it. I see that's the benefit. Ah rather than a short term gain, I'm looking at a long term gain. More for a D and B. **Ok so you don't see many benefits during the construction phase or...**No I do but I probably need them proven to me. There's an element of I just don't know. Where have the, where the issues for myself have been is that um designers have a hard enough time right now keeping up with fast track. It drives you to split your consents across 4 or 5 facets, when perhaps one would do. It drives you to value engineer on the spot, have an agreement, and almost retrospectively document if it has built what you are

building. Cos fast track does move that quick. And at the time I couldn't see BIM being, and this reflects upon us not being skilled enough to know how it would work and to, the industry knowing how to use it quick enough. When we are forcing design all the time to move faster and designers, of course this seems like an odd thing for a contractor to say, but I see them firmly in the same camp as us, having the same restrictions, which is; not enough time, and a varying degree of skill, you'll have one really good stakeholder the designer and a bunch of CAD drafters who can't um keep up or do it in time. One thing I'm getting excited about though, is the.. am I rabbiting on too much? **No, no.** One thing that I see as extremely valuable that it can add is weather tightness detailing,. We are currently paying people like *Company K* or *Company L*, and it may be them that use it. But to accurately draw how it will be built. We have all been victim to a cross section of a flashing, not shown actually how that flashing is going to perform. I might be on a raking window that drives all the water down or whatever. So it will get through a consent but it won't pass the realistic test on-site, which is will it keep the water out. And I'm getting quite excited about that. Because 3D modelling for that, we're paying quite a bit right now to develop window apertures and um engineered facades and things like that. **Yeah so that's probably coming out of the accuracy that's within the model. You can't really hide anything.** Yeah. That's right. Can it be built. Buildability. **Yep. Ok Cool and I guess that probably extends to things like clash detection.** Yep. **You know with services and structure and things like that.** Absolutely. So a reflected ceiling plan becomes extremely accurate. You know lights versus sprinklers. A classic. **Yep, yep.** **Um and so what potential barriers do you think you will have to overcome in implementing BIM? Or what has stopped you already implementing it? I mean you've mentioned the time factor.** One would be perception. People currently think it's something that is going to slow them down. So we probably need re-education. I put myself in that camp. I visited it maybe 2 or 3 years ago. Haven't done it since, so I need to do it myself. Um time. If they can convince us of time they'll convince us of a whole lot. Especially under a GMP you have GMP design and build has a design development facet of the budget. So you can entertain the cost of this if the value is right. You are not driven by the bottom line so much. So if the benefit is long term and it could work and it's going to absolutely work without question, speed up the construction time and accuracy you'd invest in it no problem at all. You wouldn't even think twice. Tender job, a bit harder, but on a tender job you don't actually own design. It's someone else's so. But a D and B GMP I could see it being extremely attractive. **OK. Um any other issues or barriers you think you'll come up against. Users. Users? In terms of....lack of training? Or what do you mean by that?** Yeah. Guys like you. Brilliant. You're coming through the industry right now. And you learn... and we need yah. Some of us have grown a bit more organically and I'm talking guys my vintage and older, are retraining so we're learning a bit more of this stuff, but again we need to get over perception. **Yeah.** Um I think we've got to be dragged through a little bit by, god help me for using it, generation Y. You're not scared of it. There's an element of fear in there. Um I think New Zealand has been slow off the mark in the previous 2 decades on the uptake of innovation. I think about how we used to do precast, you just jump the ditch and go to Aussie and go "Why aren't we doing it this way?" It's more, we're a lot more global. We get things quicker. We're not isolated. Um. I can see it speeding up. But

it will be perception. **Yep. OK. Um just got a couple more issues I've read about um with, in researching around BIM that I'll just check if you think they're going to be issues..** Yep. **One of them is interoperability, of software packages and things like that.** Yep. I'd probably take comment from other people on that, I'm a step removed from that. But yeah, exactly how do you do that. Um. Is it going to work. I mean shared information is how design teams work. How are you going to direct, how are you going to structural over architectural. **Yep. Um and what about ownership of the model. Like issues with, if you've, for example completed your contract and you have this completed construction model ah then who owns it, does ownership transfer directly to the client?** I think it's less of a problem. Um you can look. If you're worried about that under a GMP, you can put a price on it and sell it. Can't yah? So it's like when they ask for, listen I like your guarantee but I want a 10 year overall weather tightness guarantee. You say no problem, but I've priced for this and that's the number. So if you're talking about intellectual property is it any different to an architect who designs a building anyway. Not really. Um it's probably more... I've just had this issue, obviously not with this but Aconnex. Do you know about Aconnex? **Yep.** You put everything onto Aconnex, Which I love. It's a beautiful audit trail. But if the client wants to access it how does he do it. We've just negotiated a fee which keeps it open for 7 years, which is where you destroy documents anyway. Plus it gets it on a disk. I think, simply by discussing it, you'll solve it. I don't think it's going to paralyse you. **OK Cool. And do you believe the use of BIM technologies will grow in the construction industry and to what extent?** I think it will be huge. I think it has to. We build...buildings are far more complex. If you look at a secondary school now they are of university standard. Used to be able to tell the difference between a high school and university. Now you would struggle because what you are delivering is a commercial building with HVAC everything in it a normal commercial building would have, plus future proofed and running on BMS. Ah ESD is pointing us that way as well. You don't just chuck up the walls, first fix is not electrics and plumbing it is huge. If you think about multistorey high rise you can see apartments, you can see our maturity as a company, not as a company, as an industry, from when we started building apartments 20 years ago. Yep. Try servicing any of the services. It's almost impossible. They're all locked off in walls. There are no ducts, there's no spine. Now you just wouldn't dream of it. **And so if it is going to grow to that extent do you think that the main push for it to grow further is going to come from, from which group, from clients, consultants, contractors or..**Look you could put equal across. But if you are going to talk in reality it's got to come from the client. Because the client has the money. Where it will really come from, I think , the uptake will be from government. Because it's the government institutions that will demand it. Um their rules or the contracts that you get associated under are very specific. They will ask you, if you're working on a prison or something they'll say "Design me something that guarantees business as usual, i.e. this prison will operate and you will be able to detect and service a problem without cutting off services. Or that one immediate statement might lead you down this option. Um and when you're talking about developers, god they're an endangered species. The smart money might be coming free, but they're... I think the bad old days of the cheapest building, people don't want them on their portfolio. The decent ones anyway. The Ministry of Justice,

Ministry of Corrections, Ministry of Education is one of the biggest land owners. They might do it for their buildings for sure. Yep. Um. It will be government first and that is how it will come through. **Cool that was all I had.**

Interview Id	6
Company Id	D
Date of Interview	28/07/10
Time of Interview	11:02am
Age	47
Position	Construction Manager
Length of time in construction industry	28 years
Length of time with current company	12 months

So the first real question is what do you understand Building information modelling to be? That's a good question cos I had no idea what you were and what the interview was about. So um don't have any preconceived..by the look and when you said.. when I rang up and asked you for that information to prepare for it basically I didn't bother trying to research it because I thought it might undermine what you were trying to achieve. So I've got no preconceived views on it. What's the actual definition?..what is it? [reads from questionnaire] what do you understand building information modelling to be? No, no I don't have a...**don't have a preconception...** no, not really no. **So um obviously your current company's not currently using BIM on any of its projects then?** No. **No. OK. Um.** So what is it? **It is basically.. It's a level above 3D modelling, so there's a lot more detail assigned within a model so they call it Virtual Design and Construction so instead of using basically lines and dots to design things you are using objects. So the computer will identify that it is an object so you can, there's basically archived libraries where a beam is a beam, a pipe is a pipe, and when you click on that beam or column or whatever it can have ah the weight, you know what kind of intumescent paint it's receiving, with pipes you can have flow rates, you can have the thickness of the pipe, the wall thickness.** Yeah no we're definitely not using it. **Yep. OK. Um so do you know if your company plans to use BIM in the future?** It's not something that we have discussed. One of the benefits that we have, and listening to what you've just explained there is, um we're finding with our structural steel subcontractors they're probably they are using a lot of that technology with 3D combined. And we're finding that some of the comments that guys have made. By the time we get the structural steel subcontractor on site they've gone

through the pain of trying to understand and learn what they've built. **Yep.** So um I would say we probably will look at it in the future. It's not currently on the, the agenda, but it's probably something we would look at in the future. **So probably once it becomes more...More accepted...more accepted in the market and..** Yep yep. Correct. **OK. Cool. Um. So I guess if you don't really have a preconceived idea of what BIM is you probably wouldn't have a preconceived idea of what the benefits are that it would offer you either would you?** No. Again it's only based on the modelling that's been done by the structural steel possibly precast, some of our precast people have done it. But no, no preconceived how it would work, or what we'd do. The benefit that it would do. **OK. And with barriers would that be the same?** **Um.** I think it ... are you talking about barriers of why we're not using it? **Yeah why you're not using it.** Um. No I don't think there's, no from our organisation there's no real ah formal barriers for us trying anything. **Yep.** And I think if it can be demonstrated that it's ah that it has the ability. Funnily enough one of the things I had a debate about on-site today I was reminiscing about the ISO paperwork when *Company E*, I was at *Company E* for 10 years, when they went through this ISO accreditation process and what actually happened was the emphasis became on paperwork rather than delivering the building and what I've, what we've been trying to instill in our guys is that we are paid to build buildings. And buildings we can be proud of, not the paperwork we can be proud of but the building. And I think if there's um something out there that will assist us to build it better to build it quicker then absolutely we'll look at it. So from a barrier point of view it's probably I suppose a lack of knowledge that these systems are around. **Yep.** That would be the fair one, and that's the only barrier. **Yeah, yep.** So and that's why I think if it became more prevalent in the market we'd be picking up on it because it would become part of you know the designers and that whole that whole process. Yeah we'd definitely look at it. **Yeah, yep. OK.** So we don't have any barriers as such it's just maybe our own lack of knowledge is a barrier. **Yep. OK. Um. So you're probably...I'm not sure if you would have a, yeah an idea as well of whether you think it's going to grow in the market or to what extent?** Look even the um. The short answer is yes it is. I think from.. We went through again the process of building a work out at Howick where we had to support an existing building underpin it, hold it up and then build a new one. Whereas there was elements of piling and steel and things, when we actually sat probably 4 months into the job we sat down with the draftsman who had undertaken the 3D modelling we saw this building from a different perspective. Things seemed to drop in place for our guys on site, things dropped into place for me. And I think it was more a, I guess it was more a shock that someone had gone to that level of detail from a structural steel subcontractor point of view whereas if we had this modelling up front obviously, but again it's got to be brought in from the design, right through. **Yep early on.** So from a contractor point of view do you guys build them yourselves or is it part of the design process that you have the architects and the engineers doing that dovetails into them and you go from there. **There's kind of different views on it so ultimately the ideal situation it would be from the design from the designers and the consultants but then the contractor would be involved early as well so you'd have that involvement.** Yep that involvement to be able to.. **So it's really to work perfectly it should be used in a collaborative kind of working arrangement.** Yep. Where all your subbies are inputting their shop

drawings, they're not at the stage yet when you can have a central database where everyone is working on but that's probably where it will end up. So. Do I see it as a benefit? I think yes. I think it would be naïve to have head in the sand that technology changes that rapidly now and I think if there's a tool there that can assist you bearing in mind that building is simple industry. How you put it together is the key and again its coming down to how quickly you can put it together to achieve the specification standards. So if there's something that can help us put it together quicker, smarter absolutely. Yeah so I think it is a thing that ah people will move to. Again it's very hard, I think for small or medium sized building companies to invest that kind of money to get it up and running. The whole training process and I think that younger people in inverted commas coming through Unitec will be more exposed to it. They'll be the ones who will lead it and show us ah old people how to ah use it beneficially so. I think it will be used more in the future. Again it's not something that we've been exposed to really no. **Yep.** Just out of interest how many companies are, construction companies are using it? **Um I mean I've only interviewed 5 companies and 3 of them have been using it to some extent. Like no ones using it to the full collaborative..what's to some extent? Are they using it to like.. They've got models so they'll have a building modelled but then they won't necessarily be doing, cos really I mean one of the main benefits of it if you're doing accurate as-builts and everything you can um hand it on to a facilities manager then it's it can tell you when a part in the plant needs to be replaced.. so they're not actually using it in the construction phase. No they are using it in the construction phase. But they're not using it for programming. You can enter in all your temporary works and then you can actually do your programme time based through the model. Oh yeah. So you can actually do, I mean I think a lot of people are using it also for tenders, you know kind of a glossy image that the client obviously an inexperienced client..So how long does it take to input the information required. Oh it's quite a detailed process. Is it? So. Um and it's definitely a step ahead of 3D modelling. Yep. 3d modelling you know has been around for quite along time um so to a lesser extent they'll kind of be using it as information source but they won't necessarily be building directly off it. Do *Company K* use it? Um. They're using it on *Blank*. They're using *Revit* which is one of the software programmes on one building, which is and it's only for the services and that's actually.. So why hasn't *Company K*.. People look at *Company K* as leading the industry I suppose with all the.. why didn't they.. just, just to mention, inquiring more about the barriers you mentioned before. **Yep.** Why hasn't..I think *Company K* is of the opinion um that they will want a few smaller or medium sized contractors to step in to it more fully, And I think they're kind of waiting for some of the um.. So everybody's ready sitting back. Yeah kind of don't want to jump into it head first. Yeah that's..just going back to that ISO again that was something from a company perspective that cost *Company E* hundreds of thousands of dollars. Well this is I mean, just for a seat on *Revit* which is just one of the software programmes costs 12000 per person. And then you've got an issue if you've got to train the people to use it and then you've also not only got to train um someone who is proficient in the computer programme but you really want to train someone that has some building knowledge as well so it's actually... so how big is it overseas? Um in the States it's pretty big. In the**

States. **In the States it's really taken off and in parts of Scandinavia.** Can that information be transferred by internet? **Mm hm.** So you don't have to be, have to have it based here in New Zealand or can we be actually...**No. You could have a..I mean ultimately the best thing would be to have a server which everyone has access to, something similar to like an Aconnex kind of system.** Yeah, yep. **One, one system, but whether or not there's the um, I mean that takes a bit of investment as well to get the hardware to be able to do that um..** But how do you find, just if you don't mind, the Aconnex system taking off in terms of...? **I mean well the consultants all use it here, we're not on the Aconnex system because I think it was too expensive. Um but yeah from what I have heard they seem to really like it.** So you think that might be a barrier that we are going to, you're going to struggle with this in terms of like the cost aspect of it? **Oh yeah, definitely. So yep with people that are..** Being that most of us are medium sized companies anyway. **Yeah, yep.** You know and that sort of investment is massive. **Yeah. I mean the barriers I've kind of read about, there's issues with if you are having a centralised model and you've got people inputting the data then if something gets input wrong and then it gets subsequently built wrong then who is liable for that you need someone checking that.** Yep. **Also if you're getting a contractor involved at an earlier stage and having more input into the design, does some of the design liability then extend on to you or does the consultant still take all that liability?** I think you'll find that it's going to get shoved, that liability is going to get shoved down the line to the person actually doing the work. Yeah you see that anyway, regardless of whether it's a drawing whether it's a 3D model or this, this new system. That liability I think would be a barrier. **Yep.** But I think the cost is the big one. **Yeah, yeah.** You know I think that would be a big... **Yeah, and also there's issues with interoperability of um programmes.** Yep. **So obviously Autodesk and Graphisoft are kind of um not making themselves compatible because they both want market share. Yeah so and then they're also making them so that you can't down save. So you've got something that's in Revit 2010. It can't change it down to...Revit 2011. And then also cos you've got the authoring software which writes the model, so it creates the model and then you have other software programmes that...dove tail in to that. So you'll have like your one associated with programme there's also like Costex, *Blanks* I think doing a paper on that, which is basically it takes all the quantities because there's so much detail in there they can, it can zap the quantities out of the model.** So again its all about the speed but I think its, there's a huge probably process to go through here before we...**yeah and it takes a lot more upfront cost because you're putting so much into the front end of the project so...and again that probably challenges our normal um tendering process we adhere to because you know if you have a company that is factoring in those costs and he's competing against 3 other people that aren't, I'd suggest they're not going to have too much work. But you can.. I mean um one of the things, cos another one of the things is who owns the model. For example if you put together a tender model and you show how you are going to build it and you think its an amazing, or if you've thought of a way of building the building that no one else would have thought of then you present that to the client. You know whether or not they steal your idea, whether or not they can take your model and you know give it to someone else and say OK well you've got the**

cheapest price now build it this way. Um. Yeah so there's a few little hurdles to ah jump on that one. **Yep. Um, so but the last question is from which group do you think um the push will come for increased use of BIM, you'd probably need to know a bit more about BIM to really...I'm talking about clients or consultants or contractors, but you'd probably need to know...**I don't think the contractors would. I don't believe our market, especially in the you know the way it is know, but even if it was an upward market. I don't know if it would be driven by the contractors unless like for say government work. You know spent billions on roads, and let's say bridges they they um lead the way. I think the government body would be the first ones. **Yep.** Again to me it seems like something that from a contractor point of view you have to get in day one of the design process cos you'll go through a whole design process you go through costing process and you get it, you're going to spend the time to redesign it remodel it. I don't know if you would. **Yep.** Again its meant to be about saving time I take it, building smarter um who would lead it? It's probably something that is going to have to be I suppose championed by architects, engineers I don't think it will be ah a contractor to be perfectly honest. **Yep.** Unless again it's a negotiated job there's a big long term you know complex. I can't see contractors not contractors leading the charge with it to be honest. **Yeah, yep cool. OK that was it.**

Interview Id	7
Company Id	E
Date of Interview	13/07/10
Time of Interview	3:03pm
Age	27
Position	Sustainability Manager
Length of time in construction industry	5 years
Length of time with current company	5 years

So the first question is what do you understand Building Information Modelling to be and kind of what are the key components that you see of it? OK so Building Information Modelling is a term defined by Autodesk and it was largely invented as a marketing kind of term but it, it draws together the idea of collaborative working and working in a documentation space that allows multiple users to input into a single model. Um yeah, yeah that's what I understand BIM to be. **Yep that's cool. Um is your company currently using BIM on any projects in Auckland?** Yep. **Yep. Um if so. Um what proportion of projects are you using BIM on to not using BIM on.** Yeah only a small number of projects that we are using BIM as a process. Um obviously it, its really important to define BIM because a lot of people would say 3D CAD is BIM. **Yep.** And to me BIM is actually the process and not the CAD or the software package. So just because you are using Revit or ArchiCAD doesn't mean that you are doing a BIM process. **Yep.** You're just drawing in 3D, and we've been able to that for 25 years since the aircraft industry has been doing it. So it, it's not um that suddenly the invention of Revit or something has allowed for this to happen. Well it certainly has helped it along the way but it's more of a process I think. **Yep.** And that's probably more where I see the opportunity is in the process of modelling as a team, a collaborative team. **Yep, and but in terms of Company E's projects that they've got going on in Auckland is it, it's still the vast minority.** Yeah so the number of like the reason I was probably going on that tangent is because we've got a lot of projects that have been documented in Revit so. **Yep.** And we might ask for the Revit files and we can get them and use them um but the number of projects I'd say that are genuinely being run as a BIM process is very few, there's only about a couple three projects probably in the whole company so. **Yep. OK.** There's not that many. **And are they um the projects that are being run in BIM are they generally the larger projects or are they.. it's not to do with..** Yeah the size is probably is a determinant initially I think because people make that initial software investment, they want to recover it over the course of a project. Perhaps a series of projects but provided they can recover it through one project early on it sort of eases the pain if you like of that um potential barrier that that capital cost is. **Yep.** So you know a one Revit licence is 10, 12 grand or something so there's quite a big capital cost initially so I think what we've probably seen is and we're still starting to see is there are still consultants out there that haven't sort of gone down this track yet. They're usually using a big project to jump into it. **Yep.** Um but then saying that consultants that we have been working with for a while that have been doing BIM for a while are doing it on all of their projects so we've got a couple of small ones and a couple of bigger ones. **Yep. Um and how.. how has the company decided whether or not it's going to use BIM. Has that been decided by you guys or is that been decided by... the client, or consultants or?** Yeah so it's a little bit of bottom up and little bit of top down. I think the um the more well educated clients or the clients that have got really good consultants who.. I suppose they're a bit progressive and they're not trying to stick to traditional models of developing projects and designing and documenting things are leading it a little bit and they are coaxing their clients into it. Saying you know this is good value for money. **Yep.** Um rather than resolving clashes on-site during construction lets resolve them early. Let's spend a little bit more time in planning. Um and then you've got a bit of the bottom up which is the likes of the Mainzeals or the Fletchers or whoever saying we can see the value

in these tools. We're pushing for the consultant team to be using BIM as a process. We'd like to be a part of that process this is what we think we can add. So you've got sort of from both directions. **Yep. Um and you mentioned before that um working out of.. Like a communal database or information set, the one.. the projects you have used BIM on has that been like a collaborative or partnering arrangement? Or has there been open information sharing on those...** Yeah. Um. I think there's still a lot of people who are nervous about IP. **Yeah.** Um particularly consultants and they're a little bit reluctant to give out their models. **Yep.** So they'll build up families of parts or sort of libraries and they don't necessarily want to relinquish all that IP that goes into those. **Yeah.** You know it might take someone a month to create one library part for some tricky component. And they don't want that to sort of become general public IP so um there seems to a little bit of reluctance in the market but I think generally speaking as ah people like Masterspec start making a lot more products anyway. **Yeah.** And you know there's a lot more information sharing generally speaking a lot more transfer of information. **Yeah.** Um. **But have the contractual structures on those projects, have they been kind of like a traditional contractor subcontractor role as a...** Yep um. They have been.. a couple have been traditionally procured but um, probably our best.. traditional procurement by its very nature is not very conducive to doing a good BIM process it's too linear and it doesn't allow contractor subcontractor engagement or um collaboration. So I think by its very nature its definitely going to be a hard process or a hard way to run the process under the traditional model. **Yep.** Um. But yeah so we've had a couple that have been traditionally procured that have kind of run a BIM process but the best opportunities for us have been in design and build. **Yep. OK. Um what benefits has using BIM technologies presented and have these increased as experience with BIM has increased? So as you've used it more have you found the benefits to increase?** Yeah probably still really trying to get a good feel for what the benefits are and trying to evaluate those benefits against um the additional time that goes into.. I suppose the front end loading of design and our time that's spent on that process so probably a little bit too early for use to say on that one. Um but we are definitely seeing benefits and we're seeing a lot of projects where the level of documentation or the standard of documentation is increasing and there's less coordination between designers and so there's definitely.. you can see a lot of potential there. Put it that way. **So so the benefits you have seen, one of those was coordination.** Yeah obviously that's one of the biggest benefits is um good coordination of drawings. **Yep.** Between, yeah services and structure and architecture all those tricky interfaces and all those things that sort of look OK when you see it in 2D but when you pull the model together with shop drawings and actually start investigating the detail of it things just don't line up. **Yep.** You've got plumbing going through ductwork and all sorts of clashes so. I think you know any main contractor would tell you that's got to be one of the biggest opportunities to reduce wasted time and cost. **Yeah. Um I've just got a list here of benefits that I have found in the literature that they've talked about.. I just want to know if you know if Company E have found them as well. Um so one was increased prefabrication through the level of detail that's in the model.** I don't know of a lot of prefabrication that's been pulled if you like the information for prefabricating elements has been pulled from the model. **Yeah.** It's more the other way around at

the moment where subcontractor's shop drawings are being integrated into the model. **Yep.** I think, yeah. **OK.** That's just a New Zealand thing probably but...sort of the way I see it at the moment. **Um. The programming of or scheduling of ah the whole contract has that become more accurate. Do you know?** No. Definitely not. Our guys haven't really gone too far down that track. I suppose our guys say well we understand a programme and how it operates and we understand how to read a Gantt chart. We don't need to see it visually to know how to do that. **Yep.** Um the perceived benefits of the 4D scheduling type process that they are doing at the moment. Our guys perceive that, or some of our guys anyway, perceive that that's more a benefit to people that aren't construction people. **Yep.** So your client can sort of see the impact, they can see the progression they can see how things are changing but... Yeah I think um yeah I think from a sequencing point of view there are definitely advantages but perhaps those advantages aren't as great when compared to the cost and the time input required to build up a good accurate 4D model. So it's not there aren't benefits it's just that the cost benefit might not be as good as it is for a clash detection function. **Yep. Um quicker and more efficient communication methods. I guess through that you know you can have your automatic updates through your drawings the different layers.** Yep yeah definitely. Yep seen that. **OK. So the next question is what issues or barriers has the company encountered in using BIM and how have these been overcome?** I think one of the major issues at the moment is um for main contractors is because we don't have large numbers of CAD technicians or draftsmen or you know people who would be using the software our role primarily has been you know managing the construction process not documenting the project and so we're going to end up with a large number of um low tech users I guess or less experienced less skilled users and the real challenge for us or one of the challenges that we have at the moment is do you make the investment in a lot of software and a lot of training for a large number of users who might only use it for a couple of hours a week, the software. So, so the software itself is.. is expensive and Autodesk are probably loving it um. Yeah I don't know whether or not you know the price will come back as its adopted more and more but I suspect not um and I think that's always going to be a challenge for main contractors is that decision to actually invest in the people who are good competent Revit users or ArchiCAD users. **Yep.** And the software and the hardware it, it's everything your server has to be upgraded you have to upgrade your hardware individual machines and you've got to train your guys and you know there's a new revision of Revit every year and it changes every year so you've got to pay for the upgrade licence so it is quite a major investment and it's probably one of the real challenges is the training as well so they.. experienced site engineers might be in their 40s or 50s and you know they struggle to use email let alone [laughs] I know that's a bit harsh but you know they'll be confident users of basic Microsoft Office tools, Project things like that, but they've not had a lot of experience with any kind of CAD you know they might know how to look at a CAD drawing on their screen but not manipulate it or play with it or actually extract useful information out of it. **Yeah. Um. Any other barriers or..?** yeah well at the end of the day it's, it's a tool for people and I think the people in the construction industry haven't really been exposed to these tools for very long, from a main contractors point of view any way. **Yep.** A lot in the past and that's going to be the major one I think is getting the

people up to speed and getting them to buy into it and understanding that there's some value in it and it's worth their while learning how to use these tools and apply them. **Yeah. Yep. Um so I'll just do the same thing as I did for the benefits um so you mentioned that the um that some of the projects you've done collaboratively using BIM has that, from *Company E's* perspective increased their liability in terms of maybe design liability or data.. the liability associated with data entry into the model.** Yeah probably not. I don't think. Do you mean has it increased our liability or is their a perception that it has? **Um both in a way I guess. More has it actually, but then whether or not the perception...** I think strictly speaking that you know you'd have to go to the details of the contract and find out where the liability for design lay but at the end of the day typically speaking the design responsibility is with the design team still. Um obviously within a contract environment to a main contractor so you know ultimate delivery of responsibility in a design and build contract is with the main contractor but that that risk of design is moved on to the design team. **Yep.** Um so I don't particularly feel that it's exposing us to additional risk. In fact it's probably de-risking it for us because we get the opportunity to challenge the design early and really make sure we're happy that our design works and it can be built so we're de-risking the design in the sense that we're adding all that buildability to it and the clash analysis all those sort of issues are resolved early in the process so it's probably de-risking instead of adding risk,, for us. **Yep. Um any issues with ownership of the model?** Yeah there are going to be challenges with ownership um. We've already seen it a little bit on traditionally procured work where you've had a reluctance um for people to share their model um designers to share the model and that isn't BIM anyway you know cos the process itself requires everybody is collaborating on the model so if somebody's trying to hang on to it it's 3D CAD it's not BIM. Um yeah so there are definitely issues of ownership. **Mmand at the end of the project is the ownership going to the client?** Yeah well that's probably the angle we've approached it from is that we're all trying to get a result for our client whether it's the architect or the engineer or *Company E* we're trying to do the best we can for our client and if that means that you know the consultants share the model early and everybody sort of gets together on that and the end result is that the client has really good 3D model of their building um which allows the contractor to go on and build it really well and they end up with a really good quality product all the better. Um I think there's still an unresolved question, a little bit unresolved anyway, whether or not the client is going to want or what they are going to do with the completed model. So all of this comes back to, well a lot of it comes back to the level of detail. **Yep.** And um you've probably sort of looked at this yourself but I think one of the challenges is, oh I didn't say that in the challenges but you should add it to the challenges is knowing what level of detail to model things to that's definitely a challenge and you know. It reflects in the cost of doing modelling but you know people say we're doing BIM and we're doing this awesome you know BIM process whatever but they've just drawn some boxes on a page literally there's no detail in the model and there's you know the model lacks any detail to actually go in and interrogate components or you know it's not parametrically accurate or there's clashes in the model still because it's never been coordinated properly even though you've got a model there um and that is definitely one of the big challenges. But then carrying on that level of detail discussion um

what, the level of detail really dictates what construction use the model has. So if you have a model that is at a very high level of detail and it's continually updated throughout the process, the construction process, you end up with an as-built model effectively. That I think would be a very useful thing I think to a building owner, from a facilities management point of view or whatever. Um if they want to do future additions or alterations to the building they know where everything is and it would serve as ah... they know they're not going to drill through a pipe or.. but if you take the other extreme um a model that's supposedly BIM or whatever that has a low level of detail it may be of very little use to the client once they are operating the building. **Yep.** Apart from maybe rendering or maybe doing a glossy magazine picture or anything. **Yeah yeah.** And at the moment to be honest that's the main, or it seems to me to be the main thing clients want from a 3D model is the ability to render it and use it for marketing and attracting new tenants to their building. **Yeah.** Which is a you know it's a valid and its genuine reason but it's certainly not extracting all that useful information. **Yep. Um have you guys had any issues with interoperability of software?** Yes. **Yep.** I think that's going to be an issue for everybody. **Yep.** And um Autodesk are compounding it by making their software not backwards compatible. **Oh right yeah.** On purpose. Things like that. So they're really trying to get people to update to the new version every year. **Yep.** Um. Things like that and they're also not really playing the game with um sharing file formats so instead of developing some industry standard file formats they're really trying just to stick their own. **Yeah, yeah.** Um to protect market share and it's quite anti-competitive I suppose in the strictest sense but... yeah interoperability is going to be a challenge. There's lots of clever stuff out there like file format converters and things that people have been developing but yeah I suppose you lose information every time you change from one file format to another so if you can keep it in a common format it's the best thing. **Um. Do you believe the use of BIM technologies will grow in the construction industry. Um and if so to what extent.** I do believe they will grow quite a lot. Is that very accurate really, probably not but I think there is going to be a threshold level at which consultants don't engage particularly. So you'll have maybe your solo practitioner maybe architect who does residential construction may never be particularly interested because at the end of the day he just has to knock out a set of 3604 kind of compliant timber house building drawings that he know council will rubber stamp and he knows the cheapest way of getting there is the best way of getting there because his client is driven by the dollar, **Yeah.** And you know the builder just usually makes it up on-site anyway because it's all pretty non-critical and um whereas if you get to a sort of larger commercial scale construction I think definitely that's going to be a lot more adoption of a BIM process. The thing that's really going to determine to what degree its adopted is, one of the things that will anyway is the procurement model and if we stick to a traditionally procured sort of approach where it's hard tender and lowest costs ignore the value kind of approach then yeah I don't think it will be adopted to anywhere near the same degree as if we go to a more performance based contracting. Like a design and build type scenario there's a lot more opportunity. **Yep. Um and from which group do you think that the increased push towards use of BIM will come? Will it be from contractors, from clients, consultants or from someone else?** I don't think it will come from clients because... I just do not think it will come

from clients..yeah for a start they don't understand what's... most clients don't understand what's out there and they don't particularly care, I don't think and nor should they. At the end of the day they look at the key units of measure for them is the dollars, the functionality of whatever it is, the time it takes to build it, reputations they don't want deaths and things associated with their project. **Yeah.** Those are the typical kind of things they'll look at and they'll judge you based on those and it's more for the project delivery team to say "How are we going to maximise benefits to the client?" **Yeah.** Using every tool available. Not saying that BIM's a silver bullet but using every tool available so we can have better plant, better communication, we're going to work together. And so I think contractors and consultants are going to have to team up a lot more and think about challenging traditional thinking about where cost is brought into a project and where a time and delay is brought into a project, if that's a key determinant for our client. At the end of the day the client will drive it, but they won't drive it directly saying "I want BIM" I don't think. They'll say "I want a cheaper building. I want a better quality product. I want a building that doesn't leak. **Yep.** I don't want anybody killed on my job. You guys figure out how to deliver that. And I think it's for us as an industry, main contractors definitely, to be leading that and saying "Well. Yeah We think that by modelling the building methodology we can reduce our LTI rate because we know we are not going to have any injuries because we've thought about the process" or whatever. **Yep.** But um yeah. Where you may see in an extreme circ.. in a rare circumstance you may get a very well educated client who's said "I want BIM cos I've done my research and I know it's a good process and um.. in much the same way as you have clients now who say I want early contractor involvement. Because they have done their research and they know it..by and large it produces better outcomes. So there will be the occasional client who says "Yes. I want this. And I want you to pitch to me that you can do it. And you're going to work as part of a team and yeah." **Cool that was ah, that was the last question. Sweet. Thanks for that.** No worries.

11 Appendix D- Interview notes

Interview Details	
Interview Id	1
Company Id	A
Date of Interview	13/07/2010
Time of Interview	11:01am
Length Of Interview	17 minutes
Age	42
Position	Auckland Regional Manager
Length of time in construction industry	25 years

Length of time with current company	22 years
Definition of BIM	
Correctly identifies BIM as greater than simply 3D drawings and specifically mentions potential relation to time and cost, noting that they have used up to 6D.	
No mention of collaboration when defining BIM	
Use of BIM	
Use of BIM on projects that make up 80% of revenue, but only 20% of projects overall	
Not using all aspects of BIM on the projects where it is being used, ie no 4D, and 5D. Essentially as 3D drawings, however they have used BIM up to 6D before.	
Have used BIM in both collaborative and traditional project arrangements	
BIM use is generally restricted to projects over \$60 million, however it has lasso been used on a \$35 million job	
Benefits	
States that main benefits of BIM are to the client due to potential use for facilities management once construction is complete	
Increased visualisation through 3D drawing	
As a sales document for the client marketing the building- again not to contractor	
Coordination of design through preplanning; including clash detection and the like. So that the issue is resolved prior to it being discovered on-site	
Does not believe that prefabrication is currently a benefit	
Does not believe that more accurate programming is a benefit	
Does agree with greater communication is a benefit	
Barriers	
Main barrier is finding someone to pay for the modelling process	
Issue of not being able to build directly off the model as the architect will not warrant that the model is correct as otherwise they will not be able to buy insurance	
Ensuring that the model is labelled correctly and built to Standards	
TA will not accept 3D drawings for consent purposes, will only accept 2D drawings	

Agrees that design and data input liability are increased using BIM
Agrees that there is an issue surrounding ownership of the model, however does not view it as a major issue and one that can be overcome
Interoperability is an issue, however this again has not been a major issue and has been overcome
Cultural issues of trying to persuade older members of staff to use computers
Growth and Drive for BIM use
Believes that BIM will grow to be used on 100% of 'good' commercial projects
While their company has been pushing for an increased use of BIM, believes that the main drive will come from architects as they are already drawing in 3D so for them to add the detail the contractor wants is not that much of a step up

Interview Details	
Interview Id	2
Company Id	B
Date of Interview	15/07/2010
Time of Interview	9:01am
Length of Interview	26 minutes
Age	46
Position	Services Manager
Length of time in construction industry	23 years
Length of time with current company	7 years
Definition of BIM	
A huge database which can have defined parameters and 3D drawings. As many parameters as someone cares to input	
Sees BIM as an outcome of Revit, defining BIM as the concept and Revit as the tool, yet still sees the options and analysis layers associated with BIM	
Use of BIM	
Currently using Revit on the project he is working on but only in a limited sense. As-built of the mechanical trade are part of the project deliverables, but the consultants are not willing to share their model data. Only being used for the MEP	
Has been <u>no</u> overlaying of structural, architectural and services models	
Generally limited to use on big projects due to the capital outlay	
As the libraries are not fully developed the consultants have used pipes to model ducting items; hence visually the model may look correct however the data attached to the elements of the model are not necessarily right	
Benefits	
Spatial coordination	
Visualisation through fly throughs	
Parametric data attached to the model offers a greater level of detail	
There has been an increased use of prefabrication by the mechanical subcontractor; which is the trade that is producing the as-built model to be handed over	

Not aware of the ability to use the programme in conjunction with time based elements
Barriers
Hardware of the company has not yet reached the requirements needed to drive the programme adequately
Data libraries are not established enough
Lack of training and education
Cost of investment and for some trades the benefits that it creates will not balance out the costs
There is not yet the platform for the collaborative use of a single model as the medium in terms of connections speeds is not available
No standards for placing definitions on how you describe a parameter
Interoperability even in the versions of Revit and the like not being able to save in different generations of the software
Growth and drive of BIM use
BIM use will grow to be the primary method of design documentation
Drive towards greater use will come from the consultants
Easier to model something than provide the details behind a connection as these have to be developed out of shop drawings which are done by the subbies

Interview Details	
Interview Id	3
Company Id	B
Date of Interview	20/08/2010
Time of Interview	11:59am
Length of Interview	23 minutes
Age	45
Position	Auckland Construction Manager
Length of time in construction industry	23 years
Length of time with current company	21 years
Definition of BIM	
3D modelling and design documentation process that can include programme	
No mention of collaboration	
Use of BIM	
Currently using aspects of BIM, or BIM software products, but not carrying out a full BIM process	
Benefits	
Allows highly complex situations to be visualised and understood	
Clash detection, again particularly with services and structure	
Sequencing and coordination benefits in terms of analysing different strategies for the construction of a building. Although not currently using this aspect of BIM does see this as being a benefit in the future	
As a marketing tool for companies selling themselves to clients at the tender stage by being able to show how they intend to build the building	
Increased opportunity for prefabrication for subcontractors	
Easy for clients to view exactly how the project is tracking without having to examine the programme in detail	
Believes one of the goals of the BIM process is for the subcontractor to take the information in the model to translate directly to his CNC cutter, bring the prefabricated element to site which at the same time is entered in to the as-built model, a seamless process. "We are nowhere near that now" though	

Barriers	
Interoperability also that some of the early adopters of 3D design tools, such as the structural steel subbies, are using programmes that do not easily convert into BIM file types	
Expensive, the implications of this for smaller firms will be greater as they may not be able to afford to adopt the technology	
Interoperability also in terms of the generation of the software that is used to generate the model	
Ownership; if the subcontractor has developed aspects of the model who owns it, and the IP that goes with the ownership	
The IP presents itself in a way that is you do tender with an idea of how to build something the client can potentially take a flash drive and pass that information on to competitors who may steal your ideas.	
Believes that the barriers will drive a different form of contract, movement away from the traditional contract structure	
Consultants are not currently prepared to hand over a workable model as they do not want to take responsibility for it, hence there is a doubling up of work, a waste as the contractor and the subbies must develop a slightly different model.	
Does not see resistance to change as an issue, sees the introduction of the technology as aligning with the development of CAD programmes	
The level of information that is contained within the model makes it harder to hide costs, which contractors often do under a traditional contract. Also makes allowances for waste difficult to agree or price.	
Lack of training is an issue, but only as it is a new technology. However must be aware of training people that are computer literate but not experienced in construction. Will attract more drawing related people rather than construction related people	
Difficult to detect quality of drawings when they are 3D as may look right even if they are wrong	
Growth and drive of BIM use	
Different drives for greater use; some of the sub trades will drive it in specialist areas, such as structural steel and services	
Main contractors will use it mostly as a marketing tool for tendering jobs	
Long time before it is being used as a programming and cost control tool	
The drive for main contractors will come through the sub trade market	
Consultants will also form part of the drive towards a greater use	
Interview Details	
Interview Id	4
Company Id	A

Date of Interview	19/07/2010
Time of Interview	10:04am
Length of Interview	23 minutes
Age	34
Position	National BIM Manager
Length of time in construction industry	10 years
Length of time with current company	8 weeks
Definition of BIM	
Defines BIM as virtually constructing a building prior to the actual work on-site.	
Identifies different levels and uses including association with costing and coordination	
No mention of collaboration	
Use of BIM	
Selection of which projects to use BIM on is currently size based. Smaller jobs it does not regain the extra cost associated with modelling the building	
Currently using BIM technologies on projects, but not using a BIM process to its potential, ie no use of time and cost dimensions	
Benefits	
Increased level of data detail provides benefits	
Has not experienced increased prefabrication as a benefit although does believe that this is a goal	
Has not used BIM for programming or sequencing so is unsure of whether this is a benefit or not	
Does see more efficient communication as a benefit	
"Clash detection is huge"	
Coordination through virtual construction before actual onsite construction	
Barriers	
Software packages that cannot deliver what they promise. ArchiCAD takes a long time to load and crashes frequently during use.	

Cultural issues and resistance to change, not only to use of BIM but to an increased use of collaboration
Liability is potentially increased as currently NZ contract law does not cover BIM or collaboration, people need to "accept that and wear that liability collectively"
Ownership is currently an issue as there is no standard set, if there were a standard set may define that each participant has their own model
Interoperability is a huge issue
Start up cost "shouldn't be an issue" as 10% of the cost of a project can be saved by implementing a BIM process
Lack of training is not an issue as it is a learn as you go training
Must be able to have confidence in the model which requires that it is incorporated into the contract documents
Growth and drive for BIM use
Believes that BIM will be used throughout the industry, but that it will take 20 years before the benefits are truly experienced
Drive will come from the consultants as "they're the ones that see the main benefit"

Interview Details	
Interview Id	5
Company Id	C
Date of Interview	26/07/2010
Time of Interview	12:28am
Length of Interview	13 minutes
Age	36
Position	Operations Manager
Length of time in construction industry	19 years
Length of time with current company	7 years
Definition of BIM	
Describes BIM simply as a 3D model for design. No association with the further dimensions. Not that familiar with it	
No mention of collaboration	
Use of BIM	
Not currently using BIM on any projects, and have not yet used BIM on any projects	
Benefits	
Sees the main benefits as post contract; centralising on facilities management	
Increased level of detail allows for the visualisation of complicated joints which is especially a benefit in terms of weather tightness	
Clash detection	
Barriers	
Perceives that BIM will slow down the construction due to the time required for modelling	
Cultural shift in perceptions required, trying to convince people of its worth	
Lack of training	
Capital cost	

Was not aware of any issues with interoperability, although this was from inexperience rather than knowledge
Does not think that ownership is an issue as the model and its IP rights can simply be valued and placed in the contract documents
Through statement that drive comes from the client as they have the model suggests that undertaking modelling will cost the project rather than providing a positive cost benefit
Growth and drive for BIM use
Believes BIM will take over as the main design tool
Drive will centrally have to come from the client as they 'have the money'. Believes that drive within the client group will come from the government as they generally operate the facilities that they build. Ongoing facilities management benefits

Interview Details	
Interview Id	6
Company Id	D
Date of Interview	28/07/2010
Time of Interview	11:02am
Length of Interview	15 minutes
Age	47
Position	Construction Manager
Length of time in construction industry	28 years
Length of time with current company	12 months
Definition of BIM	
	No preconceptions or even idea what BIM is
Use of BIM	
	No use of BIM by the company
Benefits	
	Visualisation of 3D drawing helps with understanding the construction
Barriers	
	Only "formal barrier" is that they are unaware of the technology
	Only on reading of the list; sees data input liability as a barrier
	Cost
Growth and drive of BIM use	
	The drive will not come from contractors; believes that the drive will come from government
	Further drive will come from consultants

Interview Details	
Interview Id	7
Company Id	E
Date of Interview	13/07/2010
Time of Interview	3:03pm
Length of Interview	27 minutes
Age	27
Position	Sustainability Manager
Length of time in construction industry	5 years
Length of time with current company	5 years
Definition of BIIM	
Correctly identifies BIM as greater than 3D CAD. Does not believe that BIM is a software package.	
Believes BIM to be inherently a collaborative process and that the software is the facilitator, documentation method.	
Use of BIM	
Currently using BIM on approx 3 projects, generally larger however some smaller as well if the clients/consultants are 'progressive'	
Using Revit as well on more projects but does not consider this to be a BIM process	
The choice to use Revit or ArchiCAD has on some projects been from the consultants and some from the contractor	
Has been used both collaboratively and in a traditional procurement structure. Best results have been produced in collaborative arrangement, design and build	
Benefits	
States that the companies experience with BIM is not yet long enough that the benefits can be accurately stated, still trying to 'establish exactly what they are'	
Higher standard of documentation, coordination of drawings	
Clash detection	

Has not experienced prefabrication information being extracted directly from the model
Does not believe that there are benefits to be gained for the contractor in adding the 4D element, programming as construction guys know how to read a Gantt chart and can visualise the building from the drawings. While there are sequencing benefits these are outweighed by the time needed to add the level of detail required for an accurate 4D model
Quicker and more efficient communication method; automatic updates
Barriers
Time required to enter the level of detail for a model to be really useful
Capital Cost of setting up both the hardware and the software
Lack of training of operatives
Cultural issues shift required for site guys to work to that level with computer programmes. And for whole industry to engage and see the value that it potentially offers
Lots of low end users ie not fully engaging with the model having to pay for their upgrades when they may only use it for a couple of hours per week
Continual revisions of Revit that require upgrading annually which is an ongoing and unnecessary cost
Interoperability of various software packages
No increase in liability
Issues with ownership and consultants that have spent a long time detailing a family or complicated joint not wanting to share, Intellectual property
Knowing what level of detail to include in the model is a challenge, more detail takes more time but less detail means less useful
Growth and drive for BIM use
Believes that BIM will grow to be used for commercial work, standard timber framed may not be used as not complex enough
Growth will depend on whether or not procurement structures are able to be changed, whether the industry allows for a greater use of collaborative arrangements