# ADOPTION OF BUILDING INFORMATION MODELLING (BIM): AN EVALUATION THROUGH A CASE STUDY OF A REGIONAL CONTRACTOR

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***ABSTRACT:*** *The Building Information Modelling (BIM) has been adopted by construction companies in the UK owing to the stipulated potential benefits and a push for its widespread uses on a national level though the new Government Construction Strategy. Large companies in the UK and the BIM software industry have suggested that the benefits of the technology are higher than the associated costs. This paper investigates challenges and issues faced by a regional contractor specialising in building projects under most Forms of Contract, including Design and Build and Traditional Contracting. Through a case study of a regional contractor, the process of implementation using BIM framework such as BIM plan and strategies is evaluated. The challenges as well as considerations that need to be taken into account in order to achieve, if at all possible, integrated building information model through the integration of architectural, structural and MEP models are evaluated and discussed in the paper.*

***KEYWORDS:*** *Building Information Modelling, Regional, Contractor, Adoption, Challenges*

## 1. INTRODUCTION

Building Information modelling (BIM) is a term to describe a set of technologies and a group of processes within the architecture, engineering and construction (AEC) industries and the outcome is 'an accurate virtual model of a building digitally constructed' (Eastman et al 2008). The virtual model, if fully integrated, contains information on multiple facets (planning, cost, sustainability, H&S etc.) of construction projects throughout their whole life cycle such as design, procurement, construction, operations (facilities management) and demolition of the constructed facility. The development and subsequent use of the BIM models therefore require the entire project team to work collaboratively. Case studies, published to date, have demonstrated that the use of BIM will result in better quality of built facilities at a lower cost and reduced programme duration.

In May 2011 the Government issued a Construction Strategy and a mandate for a 'fully collaborative 3D BIM as a minimum by 2016'. Since publication of the strategy, the term has been widely used in the construction vocabulary (Cabinet office, 2011). The uptake in the industry currently varies between one business to another and to the extent in which BIM is used. Some companies will be gradually working towards an integrated practice and others using the minimum they can to facilitate requirements where necessary.

Many companies also pay lip service ('Bimwash') to BIM, making unwarranted claims of use and being BIM literate (BIMe 2012). Such claims could be due to BIM being misunderstood, and contractors trying to overcome the complex issues involved with its implementation or purely for the hope of satisfying clients. This is mainly because of confusion about what it is, how it should be utilised and implemented, how to resolve challenges that are faced with its implementation, where to start and how to integrate BIM within the business.

There are a number of industry wide known issues with the adoption of BIM, that are commonly discussed. The challenges are costs to acquire the technology, skills required to utilise the technology and cultural changes required within the industry. Other challenges are: ownership & transfer of responsibility of the model during stages of the project, liability and insurance and model management including change control (McGraw-Hill Construction 2009).

Clients and designers in the supply chain are favouring the technology. Large companies who have resources and the ability to go through the change process are also pushing the use of BIM in construction projects. As expressed in the UK Contractors Group report, Construction in the UK (2012), the UK construction industry is a significant contributor to the domestic economy in the UK. The report states that "when the entire supply chain is

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considered the industry contributes up to 14% of GDP and historically is a key driver in GDP." As approx. 99% of the companies are small and medium sized companies (SMEs), therefore, the importance and acceptance of any new technology by SMEs including regional contractors would be a key in its development and success throughout the industry. The challenges in adopting BIM down the construction supply chain such as regional contractors and SMEs are very significant. There are several case studies published from the clients and large construction companies, this study provides medium sized contractors perspective.

Some of the questions that need to be asked are: what is required by a contractor to meet the Governments mandate? Will BIM ensure long term growth and client satisfaction for the business? What for and how should be BIM be used? How should BIM adoption be approached? What documents should be used for its implementation?

This paper aims to answer these questions through a review of a case study of the processes used in BIM adoption by a regional building contractor and provides suggestions for BIM's use within the medium to small businesses. A number of aspects of BIM implementation were observed which include the effort gone in to the business as they commence the learning curve of producing a BIM Model, and subsequently using the BIM functions on a pilot project; the changes the team have had to make and how the team performed, along with how the key BIM Software has performed. The findings through a semi-structured interview with a director involved in the implementation of BIM are also presented in this paper.

## 2. WHY AND HOW TO IMPLEMENT BIM?

The concept of BIM is for it to benefit designers, including supply chain, project managers, planners, estimators and quantity surveyors, enabling the whole supply chain to collaboratively work together. Identified by the BIM Taskgroup (Department for Business Innovation & Skills, 2012) BIM is not software. It is more than 3D modelling but a business process, and therefore one cannot go out and 'buy BIM'. BIM is technology and a new way of working, tools which improve delivery and implementation of a collaborative culture. Depending upon the competencies and business process, 4 levels of BIM have been defined (BIM Maturity wedge, Richards and Bew 2008 cited in Department of Business, Innovation and Skills 2011).

**Level 0** is where BIM is used as a CAD tool to produce 2D drawings, as traditionally. The coordination is usually completed by hardcopy of paper drawings. **Level 1** is a basic Level of BIM and may use some 3D modelling. However information is coordinated using information management protocols. Some of the protocols are shown in the model such as Avanti, CPIC, and BS1192:2007. **Level 2** is the production of a 3D model of the building, where each element is modelled using parametric data. The model at this level will produce all 2D and 3D drawings, where if a change is made in one place, the model will update automatically everywhere. **Level 3** is an ultimate stage which is descried as 'fully interoperable' BIM. It is a fully integrated way of working. One model is created, coordinated (integrated) and shared. All work by each discipline is completed on the same 'live model' requiring all of the project team to have the knowledge, skill and willingness to work in this way. Through virtual design, as the model acts as a true representation of the building and hence supports theoretical building design analysis, to check things such as: sustainable design solutions, lighting analysis and value engineering as well as more.

In a study completed by McGraw-Hill Construction, 'The business value of BIM' (2009), there seems to be a consensus of the BIM Benefits contributing the most value to a project, including reduced conflicts, improved collective understanding of design intent, project quality, reduced design, construction changes and RFI'S, and the better cost control. In addition some key benefits highlighted in the literature include: increased communication, sharing information utilising a centralised filing for information exchange; collaborative design and construction in all project stages; pricing accuracy and a reduction in time producing cost estimates; system analysis, such as sustainability, air flow and energy modelling.

The National federation of builders (NFB) produced a report in 2012 called 'BIM-readiness survey 2012' looking at BIM-readiness in the contracting sector with responses from a broad cross-section of the industry, from micro enterprises to the very largest contractors. The survey highlights that industry will need to make this leap at a time when resources are most stretched, competition is high and lower demand for the work and specifically for SMEs, it seems far from reality. The survey indicates awareness of BIM and recognition of its importance, but a low level of understanding of BIM. It suggests that there is currently a general unwillingness to invest and develop in BIM capability. For successful implementation of BIM, it really needs to be understood what is meant by BIM and further more a cultural paradigm shift in the construction industry is needed as identified by Waterhouse (2012). This is the shift talked about in the Egan report (1998) of collaborative working, and the way to get there is education and training. This will of course be a major learning curve for many organisations such as contractors.

Many reports discuss the investment required by contractors to implement BIM. Gaining experience in BIM needs investment in many products and processes. In the SmartMarket report 2009 by Mc Graw Hill construction, they describe key areas of BIM investment as, software, collaborative working, marketing BIM capability, training, hardware, interoperability, developing 3D libraries. Training of staff to acquire BIM modelling will be one of the first start-up costs to be considered by contractors. It will be correct to assume that contractors will rely on external consultants to carry out training initially. Epstein (2102) comments that eventually contractors will develop their own in house training programmes, where staff training can then be done by in house technical experts for long term viability.

There are still known challenges with the transferring of BIM files between different software as interoperability has become a major problem. Software packages tend to work on a suite approach with specific versions for the Architect, Structural Engineer and M&E engineer to work within, the transfer of information between different software suites can cause issues. The solutions required will more than likely need to be found by the user, as they will be dependent on specific situations, for example what software is in use and what functionality is required as the output. As BIM tools are rapidly developing, the use of open file format such as Industry Foundation Classes (IFC) should provide standard BIM model where information can be shared across by the different participants in a project. This however highlights the importance a regional building contractor's decision will be when choosing which software to purchase.

The National BIM report (Waterhouse 2012) suggests research and anecdotal evidence indicate that some sectors are prepared to invest earlier than others in BIM, with medium and large scale constructors seeing the benefits and investing in the use of BIM. One of the problems with up take by regional contactors is the level of initial investment required as discussed previously. Waterhouse 2012 state this leads to contractors being unsure on up take and delays contractors while they wait for further evidence that BIM represents a good investment. They quote that "the idea BIM is only for big business is challenged by the growing number of small and medium enterprises that can demonstrate a return on investment."

The questions highlighted within the National BIM report (2012) that often are asked by contractors on BIM implementation, are "How do we get started?" and "How do we ensure that when we invest, we get a return and do not buy into a dead-end technology?" The case study discussed in this paper attempts to provide some answers to these questions.

Multiple industry standards have been published to establish a common practise across the industry for BIM protocols including CAD standards. These guidelines build up the AEC UK BIM Protocol including BS1192:2007 and PAS1192-2:2012 (AEC UK 2012). The Construction Users Round Table (CURT 2010) provides guidelines for the BIM implementation using life cycle approach in three main stages: Project Pre-Planning; Design & Construction; Operations & Maintenance. This study mainly looks at project pre-planning and design stage and the impact of adopting BIM from functional perspective. This study used 'federated model' concept where component models were combined for coordination only with component model creators retains responsibility and ownership.

## 3. FACTORS TO BE CONSIDERED FOR IMPLEMENTATION

The BIM implementation literature review highlighted a number of factors that particular affect a business' BIM implementation. The variables have been summarised in Table 1. Before a business starts it's BIM implementation the Government Construction strategy advises the maturity wedge is used to understand what level a business is currently working at and agree the level the business needs to be at or would like to achieve. The AEC UK BIM Protocol described, is the basis document for a company to use in producing its own BIM strategy. The AEC make recommendations for a high level company strategy based on the AEC protocol to be produced. The document is to assist the development of a consistent BIM across all disciplines to ensure that the coordination and information exchange process can be managed and a successful fully coordinated BIM is achieved.

Table 1: Factors to be considered for BIM adoption

| Decision Variables | Considerations |
|---|---|
| **BIM Readiness** | Review the company's position and capabilities, and ask, is the business ready and set up to be successful with BIM. |
| **Client Demand** | What clients, will benefit from BIM, can the company market its new capabilities. |
| **Government Strategy** | Government construction mandate and sustainability agenda. |
| **Staff training** | Capital required to train staff, will be one of the first start-up costs.<br>The willingness of staff to embrace a different way of working and their tolerance for change. |
| **Funding and Cash-Flow** | Business investment is needed in the form of purchasing numerous software, marketing BIM capability, training, hardware. All needing time and resource to carry out. |
| **Legal implications** | Business insurances may need to be revised, Contracts, ownership of models legalities. |
| **Technology Capabilities** | Understanding software and its functionalities and Interoperability issues with software. |
| **Supply chain BIM Competency** | How will the business integrate its supply chain? How will it evaluate which consultants to use on its BIM projects? |

# 4. CASE STUDY

## 4.1 Rationale for Using a Case Study

Case study method is used to find answers to research questions mainly "how" and "why" and is preferred in examining contemporary events (Yin, 2009). The strength of case study as highlighted by Yin is the ability to deal with variety of evidence such as documents, artefacts, interviews and observations. In the study of BIM implementation, a case study of a pilot project where a regional contractor was undertaking BIM implementation was selected. The contractor is a regional construction company operating across southern England. The company undertake a wide range of projects and under most Forms of Contract, the two main areas are Design and Build and Traditional Contracting. The project included a new school, which is a design and build project with a price of 30 M pounds. The team consists of six people, from different disciplines: structural design manager, architectural design manager, estimator, planner, MEP manager and technical department manager.

A detailed single case study method with exploratory analysis was used in order to analyse the issues that should be considered by regional contractors in BIM implementation and hence the objective was to expand and generalise theories, not statistical generalisation (Yin, 2009), and mainly to understand the BIM implementation better from regional contractor's perspective. The data collected for the case study were direct observations of the processes followed by the BIM team; the technical difficulties encountered and solutions utilised were recorded and evaluated to identify the challenges faced during the BIM implementation. The information from weekly design and BIM Co-ordination meetings, progress of work and informal discussions with the BIM team were collated. An interview was conducted with the business technical director and key points from the interview are discussed in the following sections. The findings from the case study provide lessons learned during the process and hence help the decision making process that should be used by regional contractors. The legal aspect of the BIM is outside the scope of the paper.

Normally it is expected that BIM model is produced by the designers and consultants and passed down to the contractor. The contractor can use the model to interrogate and modify information within the model where needed and use the model in assistance with the bid for planning, costing and logistics. In this case the project being design-build and only 2D drawings existed for the project, the contractor produced the model themselves from 2D information with an in-house team and employment of consultants on MEP design. The decision to implement BIM was taken as there was a 6 month period before the project can commence. Therefore it was deemed to be an ideal opportunity to use the 2D information from the school to produce a model and be able to carry out BIM functions and comparisons.

A number of key business goals were identified by senior management to be included in a BIM Execution Plan which included complete principle training for the team; develop a pilot project; develop a revised short, medium & long business plan; build in-house capability for future projects and provide fully coordinated BIM including MEP showing a cost benefit.

## 4.2 Technical aspects of BIM on the pilot project

With senior management commitment to adopt BIM and test through a pilot project, the team consisting of six people from different disciplines was tasked with the experimentation of BIM. The team consisted of a structural design manager, architectural design manager, Estimator, Planner, MEP manager, Technical department manager. The goal of the pilot project was to create a model to be used to determine what is involved with BIM and each of its functionalities, and what the software can produce. By carrying out the project, it has been realised that the software chosen needs to best fit the company's needs.

It is important before each project commences a clear objective of what BIM outputs are required and what they will be used for is understood by the whole team. These objectives will be included in a Project BIM execution plan. A BIM action plan was prepared and the team was trained with a vision to build in-house capability for future projects. A fully co-ordinated BIM for the pilot project was created, comprising of a separate, Architectural BIM, Structural BIM and MEP BIM. The fully combined BIM was used to explore clash detection procedures, 4D (3D+time) aspects of BIM, and energy modelling. The main functions of BIM have been analysed below in Table 1, different software is required to enable these functions to be carried out. The facilities management of the assets and demolition stages are outside the scope of this paper.

The BIM functionalities modelled and evaluated in the case study include the 3D co-ordinated model creation, clash detection, visualisation, sequencing, quantity take off and energy and environmental modelling, which are discussed briefly in the following sections.

### 4.2.1 Model Creation: 3D Parametric Model

The first step used was to create a 3D model with parametric and information-rich objects which can produce 2D drawings and create output files that conform to the IFC (Industry Foundation Classes).The structural and architectural models were produced separately using Revit Structure and Revit Architect by the Contractor's in-house team. The models took approximately 2 months to complete. It seemed to be a very steep learning curve for them to get it all right and the 2 months to produce the model included large elements of self-teaching (Figure 1). 'Model Development Method' (AEC UK 2010) was deployed to understand the level of detail required at stages of the model. When constructing the model, it was found from the pilot project that an unclear scope of what is required in the model and what the model will be used for, would slow down creation of the model leading to increased cost and delay to programme. During the case study it was found objects can be too simplified for what is required or over modelled, with manufacturers modelling every screw and bolt. A MEP model for the project was prepared by consultants using Autodesk Fabrication MEP and Navisworks was used for the rendering and animations.

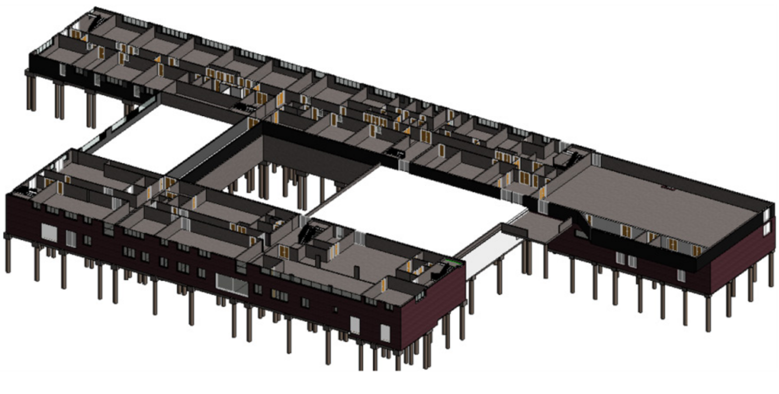

Fig. 1: 3D model of School Building with Architectural and Structural details

### 4.2.2 Model Co-ordination and Model Clash Detection

Navisworks was used to co-ordinate single discipline models into one file prior to clash detection and full design coordination. Once structural, architectural and MEP work-in-progress models were created as an entity, all 3 models were brought together and used for clash detection. The aim of the clash detection exercises was to model pinch point areas and highlight risk hotspots. Design coordination issues were clearly visible, the models were then released back to the originator to workout appropriate solutions (Figure 2).

This brought about problems, with different versions of the model still being worked on, while co-ordination and clash detection exercise were taking place. When the model was returned with the comments, an updated version already existed. A procedure was created to overcome the updating of the models. The procedure lets each designer know when they could work on the model again.

Over 1000, clashes and errors were identified during the pilot project, approximately 20 of which resulted in significant cost savings. The detailed analysis of savings was not carried out in this study. Without BIM the majority of these clashes, with duct work being below ceiling level, and interface issues with risers would not have been detected until the actual construction had taken place on site, this could have potentially caused additional cost and time to the project.

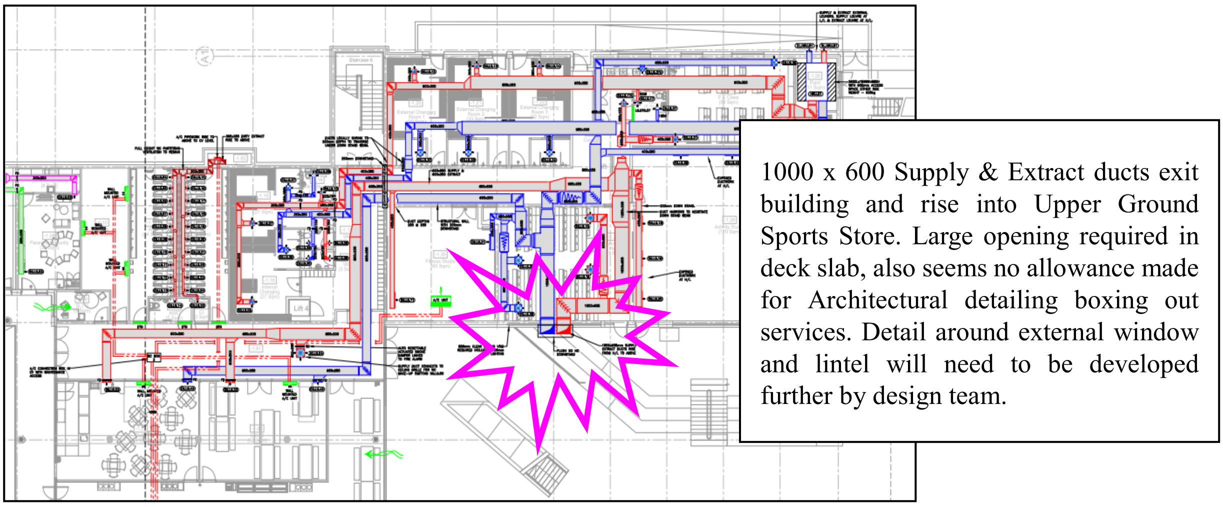


Fig. 2: Clash detection and solution

### 4.2.3 Sequencing

The programme for the project was developed in Primavera and was imported in to Navisworks along with the 3D co-ordinated model. It was found additional activities needed to be added in to the programme to provide the details required, to have a timeline to show each object in the model, this gave a more detail construction visualisation. Owing to lack of functionality to export programme activities created within Navisworks, alternative software, Synchro was used so that Primavera and MS Project files could be created directly from the software.

The model can be used to communicate to subcontractors is a better visualisation way for them to understand the construction methods on projects. This brings about more of the collaborative working and utilises other function that BIM can complete. For construction process visualisation, components library for cranes, site welfare accommodations, propping, safety platforms etc were created, which can be used again by the business saving time on modelling.

### 4.2.4 Visualisation

Navisworks Freedom worked well for viewing the model although some hardware used by staff was not sufficient to use the software well- this may be due to the specification or age of the equipment. A review of staff needing an upgrade of hardware will need to take place to utilise the software to its full potential. Some staff were also not IT literate enough to use the software, therefore some training needs to be given on using the tools contained within the software, to view and obtain data.

### 4.2.5 Quantity Take Off

Revit 3D Model was used to complete the quantity take off and compared with the traditional take off method using Excel. To develop the model, other software didn't present any specific advantages. Different measurement software linked to Revit exist: Autodesk Quantity Takeoff, Causeway BIM Measure and VICO Take-Off

Manager. The Causeway and Vico software were investigated. The comparison revealed problems with accurate comparisons with some issues in the model and the way it is built. To receive accurate quantities from BIM a set of modelling procedures needs to be adhered to. However when these procedures are correct, it is simple to extract the quantities and information required from BIM, in comparison with estimators having to carry out their own quantity take offs, or employing someone to produce a bill of quantities. Discrepancies were identified; investigation showed that most of the discrepancies were due to design changes. Some other differences were due to the differences in classifications in the traditional take off and the classifications received out of Revit and modelling inaccuracies. The way certain elements were built, overlaps in what is modelled for example would cause Revit to include the quantity of that object twice.

#### 4.2.6 Energy and Environmental Modelling

Software called Thermal Analysis Simulation (TAS) was used to review the mechanical and electrical design efficiency of the building. The model took approximately one week for the MEP specialist to draw in the software using the architectural model. Fabric U-values were added and material properties assigned to the model. The passive design measures used in the building design were tested using different fabric U-values, air-tightness and facade G-values to meet maximum solar gains, overheating and day lighting targets.

A simulation on the building, such as the amount of heat released in the building took about 10 minutes. To achieve the required figures for the project, it took 11 simulations. One of the main benefits for the business is that the MEP Manager can interrogate the model easily. For a regional building contractor, in general the M&E consultants would provide most of the information generated from the software. However being able to use the software to validate a design, to use to review high level build-ability, and challenge a consultants design was found beneficial. Overall, the co-ordinated BIM model outputs put the contractor more in control.

### 4.3 Findings from the technical evaluation

The findings of the technical evaluation of BIM model development process has been presented in Table 3.

Table 3: Technical Evaluation of BIM - Pilot project

| **BIM Steps** *(Software used)* | **Challenges** | **Problems** | **Solutions** |
|---|---|---|---|
| Model Creation *(Revit Structure & Revit Architect)* | Identifying level of details required in the model. | -Unclear scope, unmanageable file sizes, inefficient time spent modelling. | Agree the max level of detail to be included in the BIM agreed. Too little, model may not be fit for purpose; too much detail leads to large and inefficient model. |
| | Establishing the parameters required | Too much time spent adding data that may not be used in the model. | Provide a clear brief with milestone tasks for review. Do not include the details hoping it may be useful in future. |
| Co-ordination and Clash Detection *(Navisworks)* | -Various iterations of the designers' work-in-progress. | Models being updated before co-ordinated and clash detection had been finalised. | Establish model update controls such as Green Light Management system. When green light is on, model can be worked on by all disciplines. |
| | Functional models may be designed in specific software. | Interoperability amongst the models created in different software. | Establishing a common platform (if available) for all designers is key to successful integration. |
| Sequencing *(Naviswork, Synchro, MSProjec, Primavera)* | Linking model to programme. | Models produced individually until they are brought together and overlaid to produce a version, or 'issue' of a BIM model. | Use a software which has import and export functionalities, also naming different sets in the model same as operations description in the programme for automatic linking with 3D model. |
| Quantity Take off *(Revit)* | Achieving a 'like for like' on quantities. | In accuracy in model, in the way drawn, to hinder accurate quantity take off. | Estimators and BIM modellers - produce a combined procedure, for modelling specific elements that can then be used for quantity take off measures. |
| Visualisation *(Navisworks)* | Hardware requirements of staff | Hardware upgrades required as models slow or incorrect display | Business to develop computer hardware strategy for each department and establish purchasing of correct hardware. |

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|---|---|---|---|
| Energy and Environmental modelling *(TAS)* | Should the business as a regional contractor need to carry out these functions? | A role for this developed and a new person brought in to the business or an existing employee trained for the role | At high level, the function can be used by the BIM team to carry out simulations to interrogate a consultants design and review other design options. |

Through the discussions with the BIM team within the pilot project, it was evident that there is no evidence to suggest that the process disrupted company's established workflows. The learning of the software was a steep curve. In order to have integrated BIM model, lack of single platform and interoperability was still a key hurdle in the process.

## 4.4 Semi-structured Interview: management perspectives

A semi structured interview was conducted with a director involved in the decision making to adopt BIM in the company who was closely working with the BIM piloting team. 13 open ended questions were used in the interview, which are presented in the Appendix 1. The objective of the interview was to obtain relevant information about the experiences through the pilot project, questions on if the pilot project met expectations, and queries if the business now has the learning required to facilitate further BIM use in the business. The summary of the interview has been presented in Table 4 using the same variables identified in the literature review. The interviewee highlighted the benefits of BIM to the business as "BIM will definitely bring greater certainty, less errors and omissions on projects, clearer on site tracking of information, and enhanced coordination between design team members. The clarity for clients means we can help deliver their needs better, continual production of handover information, handover information in useable formats, and with the opportunity to standardise across the business."

Table 4: Interview Analysis

| Implementation Factors | Analysis Variable | Interviewee Responses |
|---|---|---|
| BIM Readiness | Motivation | Directors of the business needed convincing before BIM adoption was implemented. |
| | Investment | The business is fully aware of the costs required to implement BIM and fully committed. The businesses aimed to achieve 100% BIM Projects and all staff eventually trained. |
| | Using BIM | The business has a short, medium and long term strategy in place with BIM Implementation plans. This includes training and using BIM on site. |
| Client Demand | Using BIM | The demand from clients to use BIM on projects is still low, and a client understanding of BIM is limited. If BIM is requested by a client, the general term is used and specific project requirements are not detailed. |
| Government Strategy | Competency | The pilot project has enabled the company to ensure skills necessary to meet the Governments requirements exist within the company and associated consultants, and the company is now looking at the future to be ready when Level 3 BIM will be used in the industry. |
| Staff training | Investment | The company is committed to training staff. Although they are concerned about staff willingness to change working ways and the cultural change BIM will bring. The next step for the company will be wider communication of BIM throughout the business. |
| Legal implications | Documentation | The business plans to eventually include BIM deliverables in all future contracts. Contracts will be updated and all associated documentation to include BIM specifics and meet guidelines outlined in the CIC documents. |
| | Competency | Legalities on the model ownership, the business have used the CIC document guidelines that an output from the model will be a deliverable. Therefore an output is the same as a traditional piece of information produced; the consultant creating it, is responsible for it. However the lead designer will be responsible for the whole design, as they co-ordinate it. |
| Technology Capabilities | Using BIM | The software used in the pilot project showed many benefits, although the business needed to adapt methods to get out of the software what it required.<br>The output of BIM needs to be established before commencing a project, so a BIM can be created for specific outcomes required. The uniqueness of each project means BIM requirements will change. Therefore the definition of BIM for that project needs to be established, so the correct method, software, consultants can be chosen. The company believes the input and guidance from the team that have gone through the process will be able to establish these requirements. |

| | |
|---|---|
| Documentation | A series of documentation containing all the lessons learnt from using the software, and producing a model will be produced. These lessons will be written into guidelines, and rules for the company to produce internal modelling rules and BIM strategies. |

## 5. LESSONS LEARNED AND RECOMMENDATIONS

In the case study, problems were overcome and solutions developed, by a dedicated team, which went through a huge learning curve and cultural change, proving the success with BIM has direct relationship with the user's level of determination to succeed. Therefore choosing the right leaders to implement BIM and become experts in this field is vital.

The BIM team developed procedures and processes from first principles which has shown a truly holistic approach and in doing so identified all the benefits and best practices to be capitalised upon as well as the potential risks to avoid.

This case study also sought views of BIM implementation from all stakeholder perspectives, not only developing an understanding directly from a Contractors' perspective but also from that of the consultant and client. This enabled the contractor to proactively contribute to all stages of the BIM process and constructively challenge developments as the project progress.

One of the major sources of error in the BIM model creation on the pilot project was the introduction of inconsistent information, by different consultants and different individuals. The recommendations on modelling and other implementation variables will be used to produce a robust set of rules and standards, defining the way in which modelling should be undertaken. This can then be clearly communicated to all consultants in the form of the BIM Standard as well as the project specific BIM Execution Plan, which is collaboratively populated by the whole design team to ensure consistency, commitment and buy-in. These two documents combined then provide the backbone to the implementation of a successful BIM Project.

The decision of if, how, and when to use BIM on a project should be one of the key considerations in the initial project planning phases. The decision on whether to use BIM depends on various considerations, such as project delivery method, project schedule and cost, etc. The observations and evaluation of the BIM adoption processes in the case study suggest that a medium (regional) to small contractor should consider a number of points to successfully implement BIM, which are summarised as following.

1. Commitment and buy in from all people responsible in the implementation.
2. Identify BIM Co-ordinator for each project and BIM Champions from different disciplines to lead the process and become a conduit for the lessons learnt.
3. Identify what project BIM will firstly take place on - ie a pilot project with self-developed BIM or provided by consultants BIM model through tender or later stages of the project.
4. Ensure a willingness of team to share information, work collaboratively and integrate design with construction at project level.
5. Understand BIM functionalities and software and keep up to date with standards and code of practices.
6. Understand the maturity wedge to understand what level the business is currently working at and agree the level the business would like to achieve.
7. Train BIM champions. Training is needed to effectively implement BIM technologies. Produce a training plan for the future.
8. Communicate through the business: what has been established and what will happen, what are the business' objectives.
9. Produce a company strategy / standard document to define the standards, settings and best practices and level of details required in the model.
10. Establish best practises including guidelines for internal and external collaborative working.
11. Produce a project BIM Execution plan, detailing clear deliverables for the project and clear ownership of model elements through the life of the project.
12. Train staff on BIM, department by department (for the required function).
13. Audit processes to be put in place on projects and identify someone to audit BIM use.

As various software are required to achieve integrated BIM model, a collaborative document control system, which is also backed up by the BIM task group (HM Government, Department for business innovation & skills, 2012), was seen as essential to manage design changes and any other updates to the models and to enable collaborative working and culture.

## 6. CONCLUSIONS

In the case study project, creation of co-ordinated BIM was found to be labour intensive at the early stages of the project where lots of learning is required. A large number of object creation was required in the modelling process. However once a library of objects have been created (or is available for use), this will reduce the time in the modelling process in future projects as the objects can be reused and refined. It was identified that a series of documents establishing rules and guidelines for model creation, integration and management are required. The objective of such documents will be to ensure that the model is developed in a manner that allows the collaborative approach to continue to be used, and for the model to be fit for purpose. The study also identified that for successful implementation of BIM, it is crucial to have understanding of and follow standards such as AEC Industry standard and PAS 1192-2 and also produce a BIM Strategy Document and Project Execution Plan specific to the company requirements.

The interview reinforced the importance of senior management's commitment to BIM, and significance of developing own BIM strategy, processes and standards. This study also reiterated the need for staff training and a cultural change in the business as identified in the literature. The learning of BIM functionalities by carrying out a pilot project has helped the company to develop understanding of BIM and knowledge to use BIM in future projects. The use of MEP consultant's BIM model in the pilot project highlighted that the team needed to learn skills on the use of software to run what if scenarios and after the learning, the team were able to review high level buildability and evaluate the consultants design. This enabled the contractor to proactively contribute to the improvement of design. It is envisaged that the investment made in the pilot project would enable the company to win work and to be in the forefront of other competitors.

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## Appendix 1: Interview Questions

Q1: How did the business decide BIM should be implemented and why?

Q2: Was BIM being used before?

Q3: Have clients been requesting BIM?

Q 4: Do you believe the software used was adequate & easy to model with?

Q 5: How does the time used to complete the model compare with traditional methods?

Q 6: Were there any contractual issues seen on this project from using BIM?

Q 7: How can you see BIM will be used to benefit the business?

Q 8: Do you believe the Pilot Project succeeded and met your objectives?

Q 9: What are you short, medium and long term BIM strategies?

Q 10: How much capital was approximately invested to carry out the pilot project?

Q 11:What is your next step in your BIM implementation plan?

Q12:What challenges could arise with BIM being rolled out across the business?

Q13:What key aspects would you recommend for another Regional Contractors to use in BIM implementation?