

# A Study of the Deployment and Impact of Building Information Modelling Software in the Construction Industry

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## ABSTRACT

Building information modelling (BIM) is a technology that is currently gaining momentum within the construction industry. It allows buildings to be modelled virtually and stores information about the building in a central coordinated model. The focus of this research is to study the impacts that the deployment of this technology is having within the construction industry and any issues that maybe encountered when deploying the software.

There is little in-depth research on how BIM may affect engineering consultancies within the UK and therefore there is a need to establish the impacts that BIM will have on the industry. The research approach adopted in the report firstly consisted of reviewing the current literature on the subject. This was followed by conducting case studies of two UK consultancies in the form of face to face interviews in order to validate the former research and to provide a comprehensive assessment of deployment issues in practice.

The main conclusions drawn from the study are that while BIM has the potential to eradicate many inefficiencies within the construction industry, it is not the complete solution.

Regardless of the overall effect that BIM will have on the construction industry, it is clear from the research undertaken that the benefits of BIM are unquestionable and should be exploited to their full potential.

Keywords: Building information modelling; Information technology; construction; building design.

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## INTRODUCTION

The construction industry is widely regarded as a highly inefficient industry and relies heavily on traditional means of communications (Sommerville *et al.*, 2004). One study by the American National Institute of Standards and Technology (NIST) (Gallaher *et al.*, 2004) was undertaken in an attempt to assess the cost of these inefficiencies. It concluded that the price of new build construction was increased by \$6.12 per square foot due to inefficiencies within the industry.

Building information modelling (BIM) may be variously be viewed as type a of software, a technology and related deployment processes that have the potential to revolutionise the construction industry in terms of drastically reducing these inefficiencies and greatly increasing productivity. Demchak *et al.* (2008) define BIM as:

...the management of information throughout the entire lifecycle of a design process from early conceptual design, through construction administration, and even into facilities management (Demchak *et al.*, 2008 p.1).

BIM software, such as Autodesk Revit and Bentley Structural, work by creating a building model which is a digital representation of a building project. Information such as drawings, schedules, and visualisations can be extracted from this model and as they are extracted from the same model, all the data is consistent.

Of course, the adoption of BIM brings with it several barriers, some involving technological, sociological or legal issues (Eastman *et al.*, 2008). This has brought about a reluctance within some firms to adopt BIM.

The research conducted for this study concentrated on what could be achieved by a company deploying BIM and how they could overcome barriers to adoption. Also, a preliminary review of the literature indicated a gap in research relating to BIM deployment with regards to consulting engineers, especially in the UK. Accordingly, the study placed a considerable emphasis on this sector and the issues they face.

## WHAT IS BIM?

As previously stated, BIM software allows a digital representation of a structure to be created. This building model is constructed from instances of building elements. These elements are digital representations of components such as columns, beams, doors and windows.

However, BIM is not just a single tool; it is a collection of tools and processes that results in a product that is greater than the sum of its parts. Eastman *et al.* (2008) gives perhaps the most complete definition:

[BIM is defined as] a modelling technology and associated set of processes to produce, communicate, and analyse building models. Building models are characterised by:

- Building components that are represented with intelligent digital representations (objects) that 'know' what they are, and can be associated with computable graphic and data attributes and parametric rules.
- Components that include data that describe how they behave, as needed for analyses and work processes, e.g., takeoff, specification, and energy analysis.

- Consistent and non-redundant data such that changes to component data are represented in all views of the component.
- Coordinated data such that all views of a model are represented in a coordinated way.' (Eastman *et al.*, 2008 p.13)

From this definition, it should be noted that the concept that sets BIM apart from traditional 2D drafting software is that the BIM works with coordinated, computable data. This coordinated data is enabled through parametric modelling. Whereas with 2D CAD only the geometry of each element is stored, in BIM, building objects are assigned parameters allowing them to interact with each other and in turn dictating the current geometry of each element. For example, if the bolt size on a connection between two beams was increased, then the holes in the beams would be increased accordingly to accommodate the larger bolts.

## DEPLOYMENT POTENTIAL

Due to the nature of BIM software, there are several wide ranging benefits to be gained by deploying BIM. Despite this, the adoption of BIM in the UK has been slow compared to the US. However, it is generally accepted that BIM is finally gaining acceptance and momentum within the industry (Hobbs, 2008). Some of the main benefits of BIM that are driving this deployment are listed below:

*Accuracy and consistency of data* – All the information produced by BIM software is derived directly from the building model, ensuring that all data is consistent and accurate. 2D drawings are a prime example of this, as any drawing that is extracted from the building model will be consistent with other views, eliminating errors between various drawings. These drawings are not stored but are generated 'on the fly'. This means that any design modification made in one view will be fully propagated throughout all views.

*Design visualisation* – 3D representations can be generated from the building model at any stage in the design. These can range from simple wireframe models or complex photorealistic renders. Like the production of 2D drawings, the 3D views are produced from the building model meaning the views are consistent with each other and with other 2D drawings.

*Ease of quantity takeoff* – At any stage of the design BIM software can quickly extract data such as floor areas, material volumes and bills of quantities from the building model. Not only is this useful for quickly producing schedules, but by importing or directly linking this data into cost estimating software, cost estimates can be produced quickly at any point in the design process.

*Multi-user collaboration* – The idea of multi-user collaboration on a project is nothing new. Nonetheless, BIM makes it significantly easier to achieve by using a single building model or several coordinated models. The ease in which information can be exchanged between team members helps the project team to fully understand the project from the outset.

*Energy efficiency and sustainability* – With the introduction of BREEAM environmental ratings for buildings in the UK, designers need to produce designs that are both energy efficient and sustainable. There are several software packages that allow a designer to perform the relevant building analyses to ensure projects meet these standards; however, without the use of BIM this would require the onerous task of re-entering the information into each piece of analysis software (Autodesk, 2007). Therefore, BIM allows energy analyses to be produced more efficiently and hence is driving greener designs.

The advantage of BIM technology is greater than the sum of its parts. By looking at each individual benefit of BIM it can be seen that each element is a means to reduce cost, either

directly through better designs and reduced material usage, or indirectly through efficiency gains. Consequently, BIM technology has the potential to go a long way in addressing the inefficiency issues that exist within the construction industry.

## DEPLOYMENT ISSUES

Despite the many benefits BIM offers, the deployment of BIM within the construction industry poses many significant problems. BIM is a disruptive technology, unlike the adoption of 2D CAD which simply automated a traditional process, BIM requires a whole paradigm shift and a new way of working. Some of the more significant issues are detailed below:

*Workflow Disruption* – The deployment of BIM requires the traditional design processes to be changed to suit the workflows associated with BIM. This disruption of workflows is an inevitable aspect of BIM deployment, however, the benefits of BIM will soon outweigh the initial drop in productivity that this will produce.

*Staff and Training* – There are great demands on staff when adopting BIM software. Rundell (2005) likens training for a new technology to a balancing act, stating that it's about 'teaching the right skills to the right set of people with minimal disruption'. This issue is compounded further by the fact that there is some debate whether BIM should primarily be used by engineers or technicians (Wooldridge, 2008). With BIM software, the design evolves with the building model. This means it is advantageous to have an engineering background when producing a model as a user who knows how a building fits together will be more adept at using BIM technology.

*Legal and Contractual Issues* – Due to the large number of companies and stakeholders involved in a construction project, BIM introduces unique issues of responsibility and ownership of building models and intellectual property rights. As the building model is transferred between each stakeholder, it needs to be clear who is responsible for ensuring the model is accurate and up to date. Due to the possible threat of legal action, this increases the risk that a business takes on when accepting responsibility for a building model (Thomson and Miner, 2006).

*Interoperability* – Succar (2009 p.363) defines interoperability as 'the ability of two or more systems or components to exchange information and to use the information that has been exchanged'. As there is no single piece of software that can carry out all tasks throughout the construction process, the need for good interoperability is essential due to the large number of data exchanges required. Interoperability is a major issue and there are international efforts to establish exchange formats to address this issue.

The issues listed above will inevitably lead to a drop in productivity while BIM software is first deployed. Despite this, the benefits to be gained from BIM will soon outweigh this initial drop in productivity and the large financial outlay required.

## DEPLOYMENT IN PRACTICE

To provide a better understanding of deploying BIM software in practice, two case studies of engineering consultancies were undertaken. These were carried out by interviewing employees of these companies who were heavily involved with BIM software.

The case studies highlighted that major consultancies are utilizing BIM in some form and also that clients have significant influence over usage of BIM on a project. Some clients specified BIM to be used on a project whereas other clients weren't interested in the process as long as the end product was satisfactory. This suggests that some companies need to evaluate the cost-benefit of using BIM on a project both in the short term (when the 4D time and 5D cost dimensions can deliver value) and in the context of the life-cycle of a building.

What was also clear from the case studies was the significant differences in designing with BIM and designing using traditional methods. With BIM software the design has to be relatively clear in the user's mind before it can be modelled. This emphasises how important training can be for those involved in using BIM. The companies involved in the case studies utilized a wide variety of training methods with a range of different employees. The results from each type of training were mixed and identifying the best type of training for BIM software is an ongoing issue.

The legalities and contractual issues of BIM also featured regularly in the case studies. These ranged from being accountable for what data is entered into the building model to ownership of the model when it has been transferred between various stakeholders. Although these issues weren't perceived as hugely significant by the companies involved, it was apparent that as BIM becomes more widespread, roles will need to be more clearly defined and contracts will need to be rewritten to address this new way of working.

## SUMMARY

There is a great need for BIM software within the construction industry as the industry remains fragmented and highly inefficient. But while BIM is perceived by some as the catalyst to eradicate these inefficiencies, the research suggests that BIM is not the entire solution to the industry's problems.

Regardless of this, the benefits that BIM can bring to a company and a project are huge despite some of the issues that maybe encountered when deploying BIM. The adoption of BIM is a relatively new phenomenon and the current and future benefits that the technology can bring to the industry portray a very exciting future.

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