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The Issues and Considerations Associated with BIM Integration

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Abstract. The management of data, information and knowledge through the project life cycle of buildings and civil infrastructure projects is becoming increasingly complex. As an attempt to drive efficiencies and address this complexity, the United Kingdom Government has mandated that Building Information Modelling (BIM) methods must be adopted in all public sector construction projects in 2016. Emerging from the US Department of Defence, BIM is an approach to the co-ordination of design and production data using object-oriented principles as described in ISO 29481-1:2010. The underlying philosophy of BIM is to ensure the *"provision of a single environment to store shared asset data and information, accessible to all individuals who are required to produce, use and maintain it"* (PAS 1192-2:2013). A key aspect of BIM lies in the notion of 'interoperability' between various software applications used in the design and construction process and a common data format for the efficient exchange of design information and knowledge. Protagonists of BIM argue that this interoperability provides an effective environment for collaboration between actors in the construction process and creates accurate, reliable, repeatable and high-quality information exchange. This UK government mandate presents numerous challenges to the architecture, engineering and construction (AEC) professions; in particular, the characteristics of BIM Level 2 remain explicitly undefined and this created a degree of uncertainty amongst the promoters and those professionals charged with delivering projects. This research casts a critical lens on the current literature in the domains of object-oriented modelling of infrastructure and the associated implications for procurement and project management. A mixed-methods approach using questionnaire analysis and secondary case study analysis was used to enact an inductive research approach that captures a range of data on the practical issues and considerations associated with the integration of BIM in the industry.

1 Introduction

BIM technology has been in existence, in some form or other, for almost half a century. Within the AEC industry, the first introduction to the theory of BIM was in the late 1970s by scholars at Georgia Institute of Technology. Their research made significant contributions to technology development within the industry, and is perhaps best illustrated by Autodesk under the CAD concept (AutoCAD) in early 1980s. Graphisoft who introduced their initial "Virtual Building Solution" in 1986, now known as ArchiCAD, followed this. This was the start of the software 'revolution' that allowed architects to create virtual, 3D designs of their project instead of the standard 2D drawings.

However, this technology was only limited to designing within the architectural practices; mainly used to illustrate building materials in order to show clients and stakeholders the design of the building in the early stages. This technology allowed the design team to reduce time and increase the quality of design but was also known to be expensive, fragile and complex (Puckett, 2011); designers using 3D software still had to go through the process of producing countless specification sheets in order to express all the required information to the rest of the team.

Since the early 1990s, many other software tools have been developed to assist the roles of other professionals and stakeholders within the industry, such as project management software, programming software, planning software, and developed excel software for pricing etc. These software tools has given the industry an enhanced control of time, cost and quality but it was still a fragmented way of working as each member of the team was working on a separate software. Therefore the creation of a collaborative constructed virtual building model such as BIM was required to complete the missing part of the jigsaw of the virtual design concept as demonstrated in Figure 1.

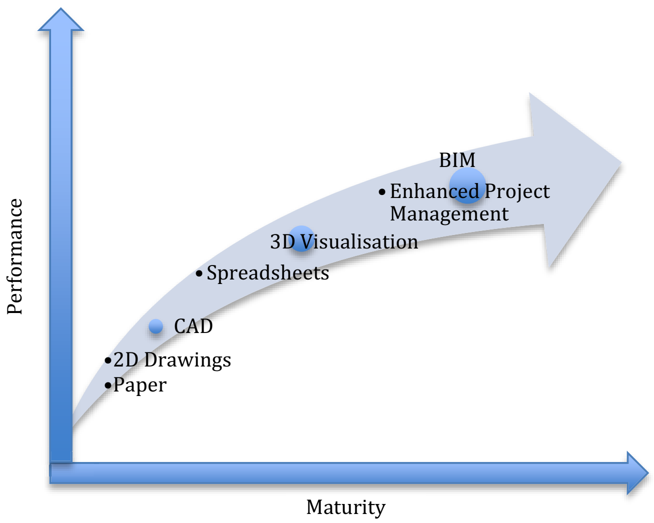


Figure 1. Evolution of technology within AEC industry

The term 'Building Information Modelling' was first used in 2002 to achieve the virtual design concept. BIM has progressed quickly since then, with many construction teams having observed values in using BIM within the construction industry; it has become more attractive with the continuous development of BIM tools**.** Today BIM is a moving target with a wide progress, becoming increasingly popular within the AEC industry throughout conferences, government strategies, companies strategies, awareness campaigns, and a wide range of journals and researches.

2. The benefits of BIM

Communication problems (whether intended and unintended) remain as much a problem in construction projects as elsewhere in business and commerce. Proponents of BIM argue that it provides a 'bridgehead' enabling reliable and regular knowledge exchange across the project organisation, with the potential to improve relationships between the architects, engineers, construction professionals, facility managers and building owners; this feature could also enable multi-disciplinary teams to remain synchronised – this should improve accuracy and enable a more informed and knowledgeable approach to decision making, which could in return reduce waste and help to achieve a successful project.

BIM is also considered to be a positive transition for designers, where they can be supported by new means of technological tools throughout the design processes, this can make their work easier, smoother and faster while enhancing the quality of designs.

Similarly, contractors can create visual data for the costs, materials and construction sequences within a shared collaborative model. Once the information data is placed within the BIM model, it can automatically present itself in floor plans, elevations, specifications, work sequences, and quantity takeoff, etc. Where all accessible users can view the information and operate on it, instead of working from detached drawings and schedules in the form of many separate paper documents. Information within BIM would also automatically adapt when changes occur to a set of data, together with a clash detection tool if changes are unsuitable. This is different to the traditional fragmented practice of numerous individual sets of drawings, where design and construction teams have to go back to manually change and re-print each set of drawings, elevation, specification, work sequence and quantity takeoff.

Case studies carried out by Kaner *et al*., (2008) and Eastman *et al*., (2008) indicated that the use of BIM in projects reduced the number of information requests and order changes; it also improved productivity and efficiency, especially in the early stages of design. A report commissioned by The Department for Business, Innovation and Skills (BIS) and HM Cabinet Office in 2008 recommended that a BIM approach could account for up to 2.5 billion per annum savings in the construction phase alone.

3 Challenges of BIM implementation

The co-ordination of activities to promote and embed BIM in the UK is achieved in part by the 'BIM Task Groups' – and whilst the overall message that has emerged has been one promoting the virtues of BIM, there is an alternative viewpoint that suggests that BIM could introduce problems that, hitherto would not otherwise have been evident using more traditional methods of design and construction co-ordination, these are summarised in Migilinskas et. al. (2013), based on four international case studies;

- Predisposition to software tools and methods of working that are familiar to the project participants;
- Focus on 'difficult' aspects of the project rather than broader application to the whole;
- Some intelligent approaches such as Virtual Project Development utilised for the first time and some concerns regarding the quality of the data used to construct the model.
- Benefits of BIM are directly correlated to the ability to maximize collaboration in project. Piecemeal adoption across the project team leads to problems;
- High costs with software purchases and staff up-skilling
- Lack of standardisation and expectations of contract obligations in certain countries or regions (such as European Union, Americas, Asia and other).

These issues might seem as great barriers to implementing BIM. However, reports and studies illustrate that BIM has been widely used around the world.

4 International perspectives on BIM

Despite the above-mentioned implementation barriers, many countries have showed great interest toward implementing BIM across the Architecture, Engineering and Construction industries. However, each country has its own arrangements and progressed differently:

4.1 United States (US)

The USA was the earliest initiator of BIM, particularly within the public sector. In late 2006 the US General Services Administration (GSA) issued a BIM-guideline outlining an implementation plan to accompany the integration of BIM use within the US AEC sector in general and the Public Building Service (PBS) in particular. Following this, in 2007 the US GSA issued a mandate to obligate all planners to use BIM while applying for GSA funding schemes (GSA, 2007).
In addition to the widely recognised benefits of BIM that the public sector appears to be gaining benefits from, the US AEC sector has established BIM policies by addressing the allocation of risks associated with the implementation of BIM, outlining the roles and responsibilities of each participating party while avoiding any conflicts with the existing construction contracts and policies. This in return has encouraged many stakeholders to use BIM as indicated by the American Institute of Architects' report on the Business of Architecture (2010), confirming that 60% of US architects were using BIM throughout their projects and still increasing yearly.

4.2 Finland

The implementation of BIM within Europe was initiated later than the USA but it has spread more quickly and exposed a wider improvement within the industry, especially in Finland (as shown in Figure 2). According to the Finnish ICT Barometer for architects in Finland (2007), 93% of architects were using BIM in projects with 33% of that usage at BIM level 3. In the same survey it was indicating that nearly 60% of Finland's engineers are using BIM in both the public and private sectors (Kiviniemi, 2007).

This spread of BIM use within Finland is due to increased interest by the AEC and Facilities Management (FM) companies in profiting from the benefits of BIM. Starting from the 1st October 2007, the Finnish FM companies focused on using BIM's modelling technology within common project works. In 2009, they established detailed modelling guidelines to assist with the use of BIM during the design stages. Later in 2009, the governing body of public properties used these guidelines to run several pilot projects; where it had a great impact in making decisions for the Senate Properties' investment processes and enhanced developments within the public sector (VTT, 2007).

BIM has also reached the private sector in Finland, where major companies such as 'Skanska Oy' and 'Tekes' took the lead of adopting BIM within private projects (Kiviniemi, 2009) Giant private companies have also funded a number of BIM related researches with local universities such as Tampere University of Technology; these researches investigated the benefits and outcomes of BIM practice within the industry to promote the integration process of BIM, developing technical tools and investigating the potential of BIM in providing sustainable solutions within the industry (Leicht *et al*., 2007; Huovila, 2008).

4.3 Singapore

The National Ministry of Singapore has first introduced BIM in Singapore in early 1995. This gave organisations such as 'Development Construction and Real Estate Network' (CORENET) an early involvement to develop and implement BIM within governmental public projects.

Singapore's government has been successful in pushing for BIM implementation and BIM standards on various kinds of projects within the public and private sectors with the help of CORENET's BIM Guideline "Integrated Plan Checking" (Khemlani, 2005). This has noticeably enhanced the number of public-private initiatives to encourage the use of BIM in a large number of pilot projects.

4.4. India

India's fast growth of population and economy have provided a boost to the building environment and provided the perfect platform to implement BIM. India has a strong workforce of qualified, trained and experienced BIM specialists who are not only implementing BIM technology in India's Construction Projects but also assisting on the implementation of BIM in Canada, USA, UK, Singapore and the Middle East regions.

4.5 Canada

The Institution of BIM in Canada (IBC) has taken the responsibility of leading and facilitating the full implementation of BIM into the Canadian built environment where they maintain a keen interest in focusing on the primary stakeholders allowing them the right method and pace to understand their roles and responsibilities and to assess their capacity to contribute in this process.

4.6 France

On April 2014, the French minister of Housing and Development announced the new "Building 2.0" which primarily contains using Building Information Model as the main tool for public projects. Outlining that BIM will become obligatory in all state owned projects by 2017. However, no plan has yet been introduced for these requirements to take place.

4.7 Continental Europe

UK, Netherlands, Denmark, Finland and Norway Governments are already demanding the use of BIM for public projects. Consequently, in November 2013 the European Parliament voted to support the utilisation of electronic tools such as BIM for public works contracts. They have described this convention as an approach to possibly enabling more efficient construction and building projects in Europe and help advance European competitiveness.

Following this decision, leaders from Europe's AEC industries have expressed their support to the European Parliamentary vote on what they described as modernising the European public sector.

This parliamentary vote is perhaps viewed as paving the way for adopting BIM and permitting all 28 EU member states to encourage, specify or mandate the use of BIM for public funded construction and building projects by 2016.

4.8 United Kingdom

The UK Government has already shown their awareness of BIM's benefits in perhaps controlling costs, time and quality and the advantages it could offer to everyone involved in the construction projects, including clients, designers, contractors, suppliers and facilities managers. On 31st May 2011 the UK Government showed its interest in BIM by publishing a construction strategy report that announced that it is aiming to adopt BIM's technologies, processes and collaborative behaviors into all stages of the life cycle of all public projects by 2016. This is expected to advance the use of BIM in the UK, as shown in figure 2. However, the UK industry is not yet ready for the implementation of BIM. The following will establish the barriers that stakeholders within the UK industry will face in seeking to implement change. Most of these issues may only appear during the implementation of BIM level 3. Implementing BIM level 2 should not create significant additional risks, but some amendments might be required to smooth the implementation process.

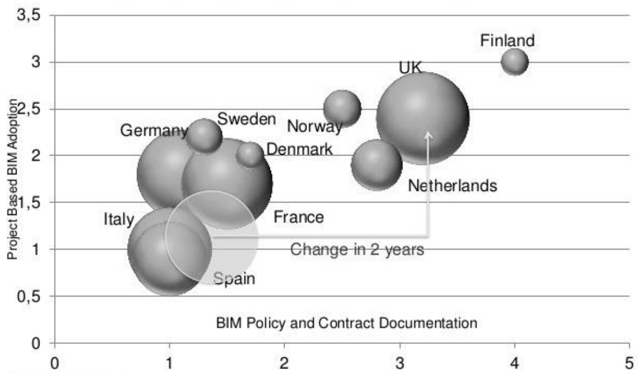
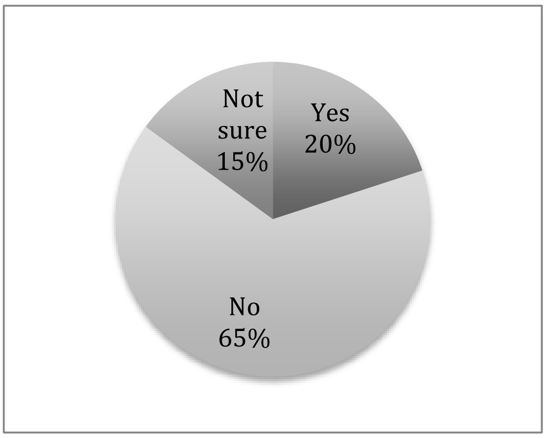


Figure 2. BIM Adoption in Europe

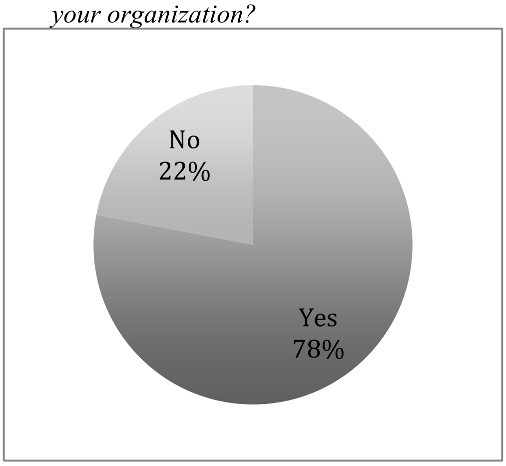
5 Questionnaire survey

In order to achieve BIM expectations and successfully implement BIM around the world, all stakeholders in the industry must reach the required BIM awareness level. To understand the readiness of stakeholders in the UK to the BIM implementation requirements, a questionnaire survey was distributed to a large number of professionals in the UK. 84 participants flagged the concern of misunderstanding BIM and its concepts. The response showing in the graphs below expresses the tardiness of many practitioners and organisations towards BIM awareness and adoption.

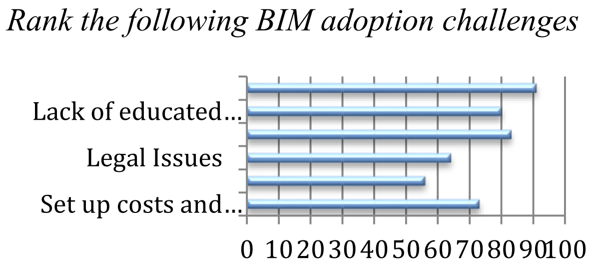
- *Are you or is your organization aware of the challenges of implementing BIM?*



- *Are you concerned about BIM adoption in your organization?*



Those participants who were concerned with BIM adoption were asked an additional question to rate their concerns of BIM adoption challenges. From the results showing below and the comments that were obtained from this research and focus groups, an outstanding distress was discovered on the concern of BIM adoption and a large number of professionals seemed to acknowledge BIM but are still unsure of what their organisation is planning to overtake the challenges of adopting BIM level 2 in the very near future. Also, despite their awareness that adopting BIM is a challenging task to many organisations, they still don't seem to know what these challenges are. Therefore, it is highlighted that a comprehensive manuscript is required to outline all the challenges of adopting BIM in the UK.



6 Discussion

No doubt, BIM can be of extreme benefit to the industry and potentially improve the way the professionals deal with projects; however, the use of BIM could raise a vast number of issues that deserves serious consideration. In essence, it is only as good as the people using it (Kirkham, 2015). Many clients are still hesitant towards the implementation of BIM as they are still uncertain and puzzled on what BIM really is. This is due to the nature of all participants within the industry and the high costs of BIM implementation owing to the required extensive training of the different professionals, cost of technical expertise, costs of organising protocols and managing a network server to store and access the model.

Other issues preventing the Implementation of BIM are the Legal barriers surrounding liability, uncertainties to the Intellectual Property Rights, digital information exchange and ownership of the program, which could all be resolved in time.

However, most of these issues would only occur while using BIM level 3. Implementing BIM level 2 should not create significant additional risks; nevertheless some amendments might be required to smooth the implementation of BIM.

BIM level 1 only contains the use of the design software features within the design stage; this level is currently used and widespread within the industry without any major implementation issues. On the other hand, BIM level 2 is an increased method in using software technologies within separate disciplines. Therefore, the following topics should be considered before BIM level 2 could be implemented within projects:

- The necessity for intense awareness campaigns and training courses throughout the industry to cover the doubts and debates surrounding BIM and enhance awareness towards the responsibilities and roles of individuals and organisations throughout the use of BIM level 2.
- Implementation of Level 2 BIM may require amendments to the intellectual property legislation.
- Contractual amendments and software measures might require rearrangements to protect users from data corruption and software tool failures especially when different users operate on the same model.
- Enterprises operating on level 2 BIM might become limited during tenders when level 3 BIM is fully implemented by others.
- A BIM protocol must be outlined and agreed during the procurement stage to address risk sharing, detailed responsibilities of all users, technology level of each model, level of definition, and an exclusion of liability. These protocols must be clearly outlined within the agreements between the client and those responsible for the BIM model (Beale and Company Solicitors LLP, 2013)

Implementation of Level 3 BIM is not just a simple step up from level 2 in terms of using software tools; it is an elevation to a very different style working. BIM level 3 will require using advanced tools within one collaborative platform; this will require a number of considerations as detailed below:

6.1 Issues Associates With Integrating BIM On Existing Buildings and Infrastructure

Attempts have been made to use BIM for old and pre-existing facilities. However, this was only possible when the existing facility was rebuilt visually in BIM or converted into the form of BIM. Although, converting an existing building into a BIM model would require numerous assumptions such as the standards and codes of the existing building design, the construction methods used, and the materials used at the time of construction.

6.2 Issues Associates With Integrating BIM On New Buildings and Infrastructure

- Cost – BIM level 3 will require significant investment from across the industry. There would be a need to take into account the costs of BIM's software and hardware as well as other costs, such as the extensive training of the different professionals, cost of technical expertise, costs of organising protocols and organising a network server to store and access the model. These costs raise the concerns of many small/medium enterprises within the industry. Failure of these enterprises in fulfilling the cost requirements will generate a large gap between them and other BIM-using enterprises in terms of recognition, work quality, winning tenders, saving time and money etc.
- Industry 'mind-set' – (Need for teaching and training) The current traditional way of working will not easily adjust to the high-tech collaborative way of working that BIM is introducing to the industry. BIM level 3 will completely change the way that professionals would approach their day-to-day duties, from

the fragmented paper method to having to work within an informational collaborative model that requires regular communication between different participants from early stages. Therefore, All existing and new coming professionals must be trained and educated to fully understand their responsibilities and duties. Also, these responsibilities and duties must be considered and drafted within the contractual documents to ensure services are carried out according to the collaborative nature of BIM.

- Information control - BIM level 3 relies considerably on IT and software systems. This reliance raises many concerns as to the need of various control procedures in order to limit and control access and inputs such as data protection with firewall systems, data backup features in case a corruption of data appears, technical support facilities and professionals etc. The BIM model is the core data platform of the project; one error within the model can be both costly and time wasting.
- Ownership – The issue of model ownership as been widely debated, where many stakeholders within the industry are concerned with who should obtain the final version of the model and the involved data. These debates are mostly due to the misunderstanding of the concept of BIM; if the model generated by BIM was correctly categorise as a product then by law it should only be retained by the buyer, i.e. the client or the building owner. However, the data contained within the BIM model is a separate issue because it is generated from contributions of various team members; they should be authorised to obtain a copy of their contribution for future records. These issues must be considered and discussed by the government to outline and verify the legal regulations towards ownership of the BIM model and the involved data during and after construction.
- Liability exposure - Different professionals from various enterprises contribute towards the BIM model throughout different stages of the product's life cycle through collaborative software systems; this new way of working might create irregular liability issues. BIM software system is protected by "blanket limitation of liability" clauses that generate the question of who is liable for any errors caused by the software tools. Another concern is who is liable if works were carried out incorrectly due to inaccurate information given by a different professional in the early stages. These risks must be dealt with and clarified in contractual protocols and carried out accordingly to distribute risk and liability evenly.
- Insurance - limited insurance companies can currently offer to insure BIM. Due to the limited use of BIM and doubtful impressions that was surrounding BIM's benefits and the risks it may incur, it was incredibly expensive to insure works done with BIM. However, now that BIM has been successfully implemented within different projects, insurance costs have decreased. For the time being, it is important for parties to consider taking out the appropriate insurance to cover their engagement in the BIM process to obtain their usual coverage and protect themselves against liabilities and risks.
- Contractual documents – BIM level 3 offers new roles and responsibilities for existing and new professions such as BIM managers and architects and draftsmen. Project contracts should include a detailed brief of these roles and outline the duties of each professional role to suit the use of BIM within projects. The same set of BIM privileges and requirements should flow through the different contracts to avoid clashes between the clauses of the principal contract and the legal terms of the BIM protocol.

7 Conclusion and recommendations

It is arguably that the construction industry can benefit from the integration of BIM in order to improve the current fragmented way of working, overtake the overpowering issues and possibly provide potential solutions and advantages to the industry. From the literature review and secondary case studies, we can conclude that BIM implementation can possibly offer enhanced products throughout the industry by:

- Reducing errors and omissions, this will make works smoother, reduce RFIs, reduce professional liabilities and insurance costs.
- Provide opportunities to discover errors in early stages, earlier error discovery reduces repair costs in comparison to discovering them once project design progresses.
- Reduce time. Where involved managers, designers and drafters can spend less time developing designs and more time providing creative solutions for clients.
- Have a positive impact on firm's reputations with an increased number, scale and variety of opportunities
- Enhance the reputation of the industry towards sustainability and efficiency
- Increased client satisfaction through visual verification of design intent
- Enhanced way of working with knowledge sharing and virtual Design before construction.

Although these benefits might appear astonishing, they are currently only presented on paper because in reality BIM could just be another idea that could not proceed due to the lack of assessment and the misunderstanding of BIM implementation process. Therefore, detailed implementation plans and arrangements are required to assist with the integration and adoption of BIM within organisations, which is currently realistically unachievable due to the numerous obstacles surrounding BIM and the difficulties of BIM execution. The demand for BIM execution plan was exposed from the questionnaire survey findings, which raised necessity of outlining and applying the following processes:

- Communicate and enhance the understanding of BIM, this could be done by providing a wide range of seminars, conferences, workshops and training courses to existing professionals in all sectors. As well as promoting the publication of articles and carrying researches on BIM.
- Organise and provide many educational and training sessions to allow the new professionals to have the correct knowledge and skills to blend with BIM applications to ensure the new and old professionals within the industry are ready for the 2016 digital BIM switchover.
- Set up clear definitions of roles and responsibilities of each different participant within the new way of working.
- Locate who is responsible for setting up the level of BIM and model standards applied within a project, and when.
- Outline the required outcomes from the use of BIM within projects.
- Examine the contractual and legal issues to find solutions to ownership, sharing, copyright, IP allocation and Insurance and issue a framework to outline the legal process and procedures of BIM.
- Establish BIM guidelines for the UK that can also be integrated with international BIM guidelines.

These themes must be evaluated and investigated by organisations to outline their unique execution plan to make the implementation process of BIM clearer and closer to reality and to overtake the issues and considerations associated with the integration of BIM in the industry

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