ACHIEVING LEVEL 2 BIM BY 2016 IN THE UK: A CRITICAL PERCEPTION OF THE CURRENT STATUS

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ABSTRACT

Building Information Modeling and Building Information Model (BIM) are terms that are often used interchangeably, reflecting BIM's growth and advantage to the expanding needs of the construction industry. Expectation about BIM's implementation and usage varies across disciplines in the built environment. Most designers and consultants view BIM as an extension to CAD and expect BIM to support integrated visualization and navigation which is comparable to the CAD software they are familiar with and some other parametric software currently in use. Contractors, project managers and facilities managers on the other hand expect BIM to be more intelligent Document Management System (DMS) which is a repository that they can extract data from in time sequence and such extracted data will mirror issues of cash flow modeling, simulation analysis and risk scenario planning as well as health and safety issues. As practitioners' differences are evident about BIM expectation, so also are the stakeholders' expectation which varies among stakeholders. In this regard the UK government being the largest public stakeholder client realized the benefits and advantages of BIM when used in procuring projects across their life cycle in the built environment. The usage and adoption of BIM in all UK government projects with a Level 2 BIM status is mandatory for UK government projects by 2016. Will this target be achievable by 2016? This study investigates the possibility of achieving Level 2 BIM status of government procured project by 2016. A critical review of the BIM literature was carried out and the evident based in relation to government target of 2016. At the current status it may appear that Level 2 adoption is achievable by 2016 for large construction firms. However, the technology needs to be properly tailored to meet SMEs variables if the Level 2 status is to be achieved for the entire industry.

Keywords: building information modeling, construction, adoption, levels

1. INTRODUCTION

The construction industry sector is highly diverse with a range of discrete subsectors with an output of around £107bn to the UK economy in 2010 employing around 2.5 million workers. It is also a key element to the achievement of UK climate change targets (HM Government 2012). The sector has undergone noticeable changes over the last six decades, which has put considerable pressure from its organizations to respond swiftly and appropriately to their requirements and needs. The need to change was well recognized in pivotal reports, including the 1994 Latham Report and 1998 Egan Report which have criticized the construction industry and acknowledged the industry as inefficient relative to other industries especially manufacturing. Furthermore, the reports claimed that the construction sector is highly fragmented, with poor levels of profitability, and slow to adopt technology and change in management and process. The issues raised in most of the reports and public commissions sponsored by the government have been implemented in some areas, most notably the way the UK government procures its projects. Presently, most government projects are procured through the Public Private Partnership (PPP) (e.g. Private Finance Initiative) that enhances the working patterns of practitioners within the

construction industry and as well as augment the way the government do business. Through this procurement route the UK government is able to off-load most of the risk associated with such public projects, but at the same time meeting the needs of the local clients with their limited funding. Since usage of the new procurement route started by the UK government several projects has been done successfully. However one of the disadvantages with this approach is that the practitioners on PPP contract projects are loosely integrated when it comes to their processes and procedures used by different practitioners (Ganah and John, 2013). One of the downside is that most practitioners and their organizations want to protect their IP (i.e. intellectual property) but at the same time present a single front to the client stakeholder, that is UK government. In this regard issues of cost escalation, time overruns, other project risks and lean management are evident in most of the reports that are coming out. Against such background the UK government realized that BIM will enhance such negative connotation about such areas and will bring about tight integration and coupling amongst firms operating within the industry. Hence one of the underlying reasons for the mandate for achieving Level 2 usage by 2016.

Although such mandate is there for full 3D collaboration at this stage that will translate to substantial cost reduction of approximately 20%, the UK Government did not prescribe in its requirements how BIM Level 2 usage will be achieved by the practitioners' organizations and their supply chain within the built environment. Such achievement is left with the practitioners and stakeholders to come up with their own solutions to meet the government minimum requirements. In this regard this research investigates how the strategic, technical and the operational requirements of BIM management is presently done. The study also looks at the way BIM education for practitioners is being done in most tertiary institutions. In this study, the scope of the systematic literature review undertaken starts from 2011 when the government issued the mandate for BIM theoretical approach, usage, and practical implementation. The rest of the paper is divided into the following sections, the methodology used in the overall research, the BIM evolution, the issues investigated with regard to BIM for practical implementation of Level 2 BIM, the discussion and then finally piecing together the various strands in the conclusion.

2. METHODOLOGY

The first step of the methodology was to use a traditional literature review method to understand the evolution and development of BIM technology up to 2011 when the government mandate was issued for BIM usage on government public projects. This method was used to ascertain the rise, usage, adoption and diffusion of BIM technology in the construction industry. From 2011 onwards, when the government mandate was issued, the research approach is a systematic review of the available literature to understand the industrial variables that have changed or the lack of it since the UK Government mandate was issued.

A systematic review is an overview of primary studies which contains an explicit statement of objectives, materials, and methods and has been conducted according to explicit and reproducible methodology. The purpose of a systematic review is to provide the best available evidence on the likely outcomes of various actions and, if the evidence is unavailable, to highlight areas where further original research is required. The advantages of systematic reviews are that (Higgins & Green 2011):

- Explicit methods limit bias in identifying and rejecting studies
- Conclusions are more reliable and accurate because of methods used
- Large amounts of information can be assimilated quickly by practitioners, researchers, and stakeholders

The guidelines for this research systematic review have been adapted from methodologies developed and established over more than two decades in the health services sector (Higgins & Green 2011) and informed by developments in other sectors such as social sciences and education (Gough et al. 2012).

The question then to be asked is:

"What is the evidence that there is an increase in the activities to the usage and uptake of BIM by organizations within the built environment on government projects?"

The research designed and used to find an answer to the above-mentioned question is an eclectic approach, embracing both quantitative and qualitative research documents. High quality systematic reviews were adopted and the following steps were carried out (Higgins & Green 2011):

- Identify all relevant published and unpublished evidence
- Select studies or reports for inclusion
- Assess the quality of each study and reports
- Synthesize the findings from individual studies and reports in an unbiased way.
- Interpret the findings and present a balanced and impartial summary of the findings with due consideration of any flaws in the evidence.

The sources used in this study came from the following in order of relative importance to academic rigour:

- Databases – the database used are those highly favored (see Table 1) by the built environment academic body as well as engineering academics. This database contains a rich source of original published research in BIM
- Government and affiliate bodies policy and other documents – the government documents are the underpinning articles that drives the uptake of BIM within the UK and as such will contain fundamental rationale that will show how far the uptake of BIM has gone. The affiliate bodies are those inclusive of the institutions of the various professionals working within the built environment (i.e. BSI, RICS, CIOB, and RIBA)
- Conference proceeding – Conferences and their proceedings are a major channel of communication among experts in any field. They are initial budding research forum from various researchers throughout the world that also contain research resources of articles from on-going research. The three chosen proceeding are ARCOM, CIB and COBRA. The last five years of publication are investigated for reliable articles.
- BIM Task Groups – is a group formed to provide help and support in delivering the objectives of the Government Construction Strategy and the requirement to strengthen the public sector's capability in BIM implementation with the aim that all central government departments will be adopting, as a minimum, collaborative Level 2 BIM by 2016.
- Social networking sites – Social Networking Sites (SNSs) are virtual communities where users can create individual public profiles, interact with real-life friends, and meet other people based on shared interests. They are seen as a 'global consumer phenomenon' with an exponential rise in usage within the last few years (Kuss and Griffiths, 2011). The social networking site that is subject specific, though informal also contain another rich resource that will make use of the way practitioners perceive the work in the future. LinkedIn is chosen as the social network that BIM forum is presently being discussed by practitioners.
- Other 'grey' literature like magazines, worldwide web were also investigated and few of them were included in this investigation.

Table 1: Selected databases used in the systematic review.

Database name	**Meta- search terms used**	**Number of articles found**	**Number of article chosen**
Science Direct	BIM, adoption, barriers	124	14
Emeralds Engineering	BIM, adoption, barriers	19	2
Sage	BIM, adoption, barriers	6	1
ARCOM	BIM, adoption, barriers	9	1
COBRA	BIM, adoption, barriers	36	1
CIB W78	BIM, adoption, barriers	2	0
Total No. of articles from the database		194	19

The search used within the systemic review process is that all documents should start in and around the time the government strategy for full implementation was issued in 2011. This will in effect follow the trend of things about BIM as it progresses from this point onwards that will be underpinned and supported by the UK

government. Anything before this period will be taken as known from the traditional literature review and how it is having impact on this study.

The criteria for the selection of reviewed articles are as follows:

- Once the database was selected and the articles pertaining to these terms are chosen, the first step was using the meta-search terms (i.e. BIM, adoption, and barriers, as well as BIM2016).
- After that the articles with such terms are collated and a further search drilling down is used (e.g. achieving BIM 2016)
- These terms were used as document analysis terms to further to investigate the evidence that are coming out within the industry.
- Please note that in this study author's H-index, nor search by authors was carried out.

The information that is relevant for the full implementation of BIM in 2016 are summarized in the next section.

3. BIM INNOVATION: ITS EVOLUTION AND DEVELOPMENT

Innovation is a process through which new ideas, objects and practices are created, developed or reinvented, and which are new for the unit of adoption (Aiken and Hage 1971; Kimberly and Evanisko 1981; Rogers 1995). Organizations adopt a range of different types of innovations to achieve service improvements, which is also true for organizations operating in the built environment. New services are offered to new and existing users, internal changes are made to the operating system in an organization, to technical and administrative processes and to intra and inter-organizational relationships (Damanpour 1987; Edquist et al. 2001). Because public organizations (i.e. the UK Government) may innovate in search of legitimacy and not fully adopt an innovation implementation has to occur (Boyne et al. 2004; Damanpour and Evan 1984) to ensure improvements can be forthcoming.

There are different types of innovation amongst which are evolutionary innovations, this involves delivering a new service to existing users. Process innovations on the other hand affect management and organization. They change relationships amongst organizational members and affect rules, roles, procedures and structures, communication and exchange among organizational members and between the environment and organizational members: they are concerned with how services are rendered (Abernathy and Utterback 1978; Damanpour and Gopalakrishnan 2001; Damanpour et al. 1989; Edquist et al. 2001).

Organization innovations are innovations in structure, strategy, and administrative processes (Damanpour 1987). In this study they include improvements in an organization's practices and the introduction of new organizational structures (Borins 1998; Light 1998; Walker, Jeanes and Rowlands 2002). Organization innovation are thus concerned with an organization's primary work activity and changes in the social system.

Technological innovations are associated with changes in physical equipment, techniques and organizational systems. Examples of technological innovations in public organizations would include information technology, hardware (physical equipment) and software (organizational systems).

Ancillary innovations are identified by Damanpour (1987) and are differentiated from other innovations because they are concerned with working across boundaries with other service providers, users or other public agencies. Thus their successful implementation is reliant upon others.

Generally, BIM innovation is a digital model of a building in which information about a project is structured in such a way that the data can be shared, although there are different definitions of BIM depending on whose perspective, for these definitions see the following publications: NBIMS-US (2007), RIBA (2012) Penttila (2006), and Succar (2009). BIM is a new innovation that is pervasive both in technology and in work processes affecting intra and inter-organizational activities.

It is widely believed that BIM will help integrating processes throughout the entire lifecycle of a construction project (Jung, and Joo 2011). Even though BIM concept has existed since the 1970s, it is only over the last 5 years building owners are becoming aware that BIM has the potential of making the design, construction and operation of buildings much more streamlined and efficient (Arayici *et al*. 2011) and BIM increasingly gain ground as a mean for developing buildings and infrastructure that are problem free, better fit for the purpose with high efficiency. However, there is a number of barrier to the implementation of BIM in the UK construction industry including but not limited to:

- resistance to change culture within the construction industry professional especially those at the top management level, and getting these people to understand the potential and realise the value of BIM over conventional design and management tools;
- training employees on BIM. This requires all stake-holders of a project to use and train their employees on BIM
- the availability of the infrastructure required for BIM including high-end hardware and networking facilities to run BIM applications and tools efficiently and components library which requires manufacturers to produce 3D models for their components in BIM compatible format;
- understanding the importance of collaboration, integration and interoperability between all the stakeholders of a project.
- lack of clear understanding of the responsibilities of different stakeholders in the new process by construction lawyers and insurers (Arayici et al. 2011).
- lack of a common language for data exchange

All of the above can only be overcome through collaboration including government, public and private sectors, industry bodies, software developers and researchers. The industry needs to become less fragmented and adversarial, and there is a strong need to encourage better integration from all stakeholders involved in a construction project. Janney (2012) and Connaughton (2012) indicate that due to the additional number or parties being involved in managing and maintaining the BIM model there could be more multi-party agreements rather than the traditional two-party agreements with which the construction industry is more familiar.

In the UK, a BIM maturity framework has been developed to ensure clear delivery of the levels of competence expected and the supporting standards and guidelines their relationship to each other and how they can be applied to projects and contracts in the construction industry.

In the UK, the government requires fully collaborative level BIM Level 2 (with all project information, documentation and data in an electronic format) as minimum by 2016 on all public projects (Cabinet Office 2011). Level 2 comes third in a four-tiered system as listed below (BIMTG 2011):

Level 0: Unmanaged fragmented (none standardized/ none exchangeable data format) CAD.

Level 1: Managed CAD in 2D and/or 3D format using BS1192:2007 (fragmented production/analysis programs, file based collaboration).

Level 2: Managed 3D environment with data attached but fragmented (discipline based collaboration and library management).

Level 3: Single, online (integrated/interoperable data), project nD model including but not limited to visualization and coordination, construction sequencing, cost estimating, procurement, thermal properties analysis, operational applications lifecycle, integrated project delivery, and lifecycle management information.

From the above, Smith (2012) argued that many projects were on different parts of their BIM journey. Most of the UK is still at Level 1 (2D/3D CAD) with regards to BIM, while some firms were seeing the benefits of Level 2 (managed 3D CAD utilizing 4D or 5D) thus for improving productivity and time management with their projects. He also went on to say that a firm's adoption of new BIM systems would be dependent on industry/client push/pull. In May 2011, the UK Government Construction Strategy was published with its ultimate aim of reducing the cost of government construction projects by 15-20% by the end of April 2014. The Construction Strategy is to implement Level 2 BIM throughout all the UK practices by the year 2016 in all projects worth £5m and over (Cabinet Office 2011).

4. FINDINGS

The results so far from the review are that:

- There are presently a number of trial projects that the government have identified and commissioned for BIM usage. Of these, only one have been completed (Cabinet Office 2012a).
- Designers and consulting practitioners are the predominant users of BIM currently

- There was a few systematic approaches but these approaches were not followed up by practitioners in the way the technical issues of BIM was being implemented, before PAS 1192 – 2013 protocol and BIM overlay of RIBA Plan of Work 2013 were developed.
- The improvement to software technology and interoperability for the BIM technical areas of implementation is moving in the right direction with 4D, and nD integration being made possible through different software vendors.
- The literature is deficient in the usage of BIM amongst subcontractors, even so with specialist subcontractors it is rare and almost non-existent
- There are no evidence within the industry of a planned strategic approach for the successful usage and implementation of BIM through the building's life cycle
- The development of BIM technical aspect is not driven by any particular software 'giant' and issues of interoperability are developing alongside open software systems.
- The task groups formed by different institutions (CIB, RICS, CIOB, RIBA etc.) are not yet fully integrated to give an holistic understanding of the underlying long-term issues about integrated and collaborative working.
- The social networking sites discussing BIM are not grounded in issues related to original research issues about BIM for them to make very meaningful contribution to the developing of BIM Level 2 adoption in 2016.
- Universities and further education colleges are not significantly engaged in new modules addressing the usage of BIM by rolling out new courses that will address the knowledge gap about this technology in the near future. So far, despite some architecture schools have incorporated the usage of BIM software in their design studios, however, it is only in the technology, but not so in the BIM management issues and its related capability it can bring.
- Very few postgraduate courses have been identified so far as solely dedicated to BIM usage and practical implementation.
- There are not many articles within journals and conference proceedings that are effective in disseminating utilization of BIM throughout the product's life cycle

From the documents examined so far it is not clear from all the practitioners what is meant by achieving Level 2 BIM by 2016. Since the government strategy did not define a road map or steps in which to achieve such it is rather difficult from practitioners perspective to achieve such.

5. DISCUSSION AND CONCLUSION

The industrial variables that have changed significantly since May 2011 are the following:

- There is now an RIBA Plan of Work 2013 with BIM overlay existing, that was not evident in the literature before 2011 that one can safely point to. This plan of work will underpin the way professional institutions and bodies plan their strategy in the usage of BIM holistically. The buy in of these institutions is lending weight to shaping the way BIM adoption will be done, both strategically and managerially.
- There is now a new protocol for BIM usage (i.e. PAS1192-2) that underpins the British Standard (i.e. BS1192 - 2007) which uptake was low as it was thought geared towards the information industry in the first take. Considering the fact that PAS was sponsored by the construction Industrial Council with sound organizational membership will improve the way BIM is procured and used. The introduction and appointment of the information manager within PAS protocol is new and not fully spelt out in relation to the issues of communication and collaboration with the other organizations that will be involved on the project.
- Most professional bodies and institutions now have task groups that actively promote BIM within their rank and files, as well as hold seminars or workshops to educate their members through continuous professional development (CPD).

- The research in educational institutions have also increased, although it is not evident there is a definite strategy in achieving meaningful results, from a more strategic agenda rather than 'firefighting' the issues of BIM as they develop.
- Most undergraduate courses in institutions now have modules that are BIM oriented or aspect of BIM have been incorporated in existing modules, which will make outgoing graduates sensitive and active user of BIM technology
- Very few institutions are rolling out postgraduate BIM courses.
- The surveys conducted by industrial groups, in particular NBS, from 2011 to date showed that there is an increase in the adoption of BIM in the industry, however, this increase in adoption was mainly by large companies, which have the resources to do so. Small and medium enterprises are still lagging behind because of lack of resources and or management strategies.

From what is seen from the work carried out in this research so far it is right to say that there are some tremendous efforts being made towards the industry achieving full Level 2 collaborative 3D BIM implementation, however, not all the practitioners nor their organizations would have reached this level. The reasons for such is the fact that in construction the issue of subcontracting is prevalent. These SMEs are actually not large firms, but have the highest of percentage concentration. Most of the large firms that get the contracts from government are within sight of full collaboration, but not so the medium and smaller firms. Again it is evident that the concentration of large construction firms in the built environment are designers and consultants and some very large contractors too. But majority of the firms that are involved in construction implementation after design and consultation and design development are concentrated in the implementation stage.

Finally the construction industry practitioners (i.e. contractors) and stakeholders need an integrated platform to collaborate and carry out an effective and efficient working environment, which is offered by BIM. So far it showed that the industry is responding positively to this challenge in most areas. Practitioners are becoming more knowledgeable through their institutions run CPD programs, contractors(i.e. large) are also informed through the relational procurement routes that they are engaged in, forcing them to change and adapt to this new forms of collaboration. Some universities are starting to adopt a multidisciplinary curriculum supported by BIM, but this needs to become the standard not the exception. The downside though is the fact that since every organization have some form of data presence in BIM there is no evidence of a federated approach that will manage the legal sharing and usage of data as each firm wants to protect their intellectual property rights. The main challenges for the SMEs is the added cost (i.e. in training of personnel, software and related hardware) and as such reduction to their profit margins. For SMEs to buy in there must be some government incentives (e.g. tax rebate/relief) that will motivate them in the direction of BIM adoption. However, it is paramount that the UK Government should continue to champion and sustain the push towards BIM adoption with more projects, achieving the goal of Level 2 collaborative working by 2016. This study is paramount for the industry as we are operating in a globalised world and as such having a persistent data platform (i.e. BIM), that can be accessed anywhere in the world will make the teething problems during the implementation stage of BIM that have been solved in the UK achievable for others without much ado.

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