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BIM Implementation Strategies – Global Comparisons

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Abstract

This paper examines the initiatives and strategies that are being used in leading countries around the world to promote effective Building Information Modelling (BIM) implementation in their construction industries. The effective implementation and use of BIM remains a major issue for the construction industry. Whilst the technology underpinning BIM has been around for well over a decade BIM implementation and take-up has been relatively slow in the construction industry compared to industries such as manufacturing and engineering. The purpose of this study is to identify and evaluate initiatives and approaches that are being used successfully by countries that are leading the way in the field.

The methodology for this paper is based on a literature review of the key global issues in relation to BIM implementation and then a detailed investigation of implementation strategies that have been developed in a range of countries and regions such as North America, Scandinavia, the United Kingdom, Singapore, China, and Australia.

The research reveals that there are considerable implementation issues. The key problem relates to quality issues with BIM models – the industry requires high quality BIM models for all professionals to be able to use the model most effectively and, more importantly, trust the accuracy of the information and data that is being generated. Nevertheless, an increasing number of countries are developing successful implementation strategies with North America, the United Kingdom and the Scandinavian region generally leading the way. A key finding was the importance of coordinated government support and leadership as a critical driver for BIM implementation.

The paper concludes with a range of strategies and recommendations that flow from the ‘best practice’ findings in the research.

Keywords: BIM, BIM Implementation, Digital Technologies.

1. Introduction

The concepts of Building Information Modelling (BIM) can be traced back to the earliest days of computing in the 1960s and solid modeling programs began to emerge in the 1970s and 1980s. The development of the ArchiCAD software program in 1982 in Hungary is viewed by many as the real beginning of BIM and the development of the Revit software program in 2000 saw a real shift toward effective BIM implementation (Bergin 2010). Whilst the technology underpinning BIM has been around for over two decades BIM implementation and take-up has been relatively slow in the construction industry compared to industries such as manufacturing and engineering. However, there has been a significant shift in momentum over the past five years as technology and implementation issues improve and the industry realizes the significant advantages to be gained from the use of this technology (RICS 2013).

As BIM evolves and construction processes increasingly become automated the roles of construction professionals will need to adapt accordingly to provide more sophisticated services that incorporate BIM technologies and will need to engage, input and share project information/data with the project team as part of the BIM integrated project delivery approach. Major private sector clients and government entities are increasingly becoming a driving force for the adoption of BIM by mandating its use on their projects.

This paper will commence with a review of current global BIM implementation trends in the construction industry and will then focus on the implementation strategies that are being successfully used by countries leading the field. The latter will be based on the research findings of an investigation of best practices and strategies from around the world.

2. Literature Review – BIM Implementation Issues

2.1. Research Into BIM Implementation Issues

Research into BIM implementation issues for the construction industry is gaining momentum (Brydea et al. 2013, Ahmad et al. 2013, Sacks & Pikas et al. 2013) and this is assisting in communicating the benefits of effective implementation to key industry players (Cook 2014, Love et. Al 2013). McGraw Hill (2014) has been tracking the evolution and implementation of BIM in the global construction industry since 2007 through extensive global surveys. They have found significant change over that period and quite dramatic implementation increases over the past few years in particular. In North America their survey results showed that BIM adoption by contractors escalated from 28% in 2007 to 71% in 2012.

Their latest survey in 2013 comprised responses from 727 contractors from ten of the largest national construction markets in the world - Australia, Brazil, Canada, France, Germany, Japan, New Zealand, South Korea, the United Kingdom and the United States. They also undertook qualitative analysis of the markets in China and India to determine BIM trends in two countries that represent approximately one-third of the world's population. They found significant acceleration in implementation. *“Change is sweeping the globe. Project teams are benefitting from faster communications, smaller, more powerful and mobile computers, robust digital modeling tools and a transformative shift toward integrated delivery processes, all of which are generating positive outcomes, efficiencies and benefits unimaginable just a few years ago”* (McGraw Hill 2014, p. 1)

They also found that whilst BIM implementation has been led by countries such as the United States, the United Kingdom, Germany, Canada and France relatively new adopters in countries such as Australia, Brazil, Japan, Korea and New Zealand are rapidly building momentum and even outperforming the more established countries in certain areas. *“BIM usage is accelerating powerfully, driven by major private and government owners who want to institutionalize its*

benefits of faster, more certain project delivery and more reliable quality and cost. BIM mandates by US, UK and other government entities demonstrate how enlightened owners can set specific targets and empower design and construction companies to leverage BIM technologies to meet and exceed those goals, also driving BIM into the broader project ecosystem in the process” (McGraw Hill 2014, p. 4)

AECOM (2013) predict that this will continue to escalate with the BIM market expected to grow from \$1.8 billion in 2012 to \$6.5 billion by 2020. They also predict market transformation in the near future. *“A sharp increase in the number of BIM projects is anticipated over the next 18 months, constituting a significant market transformation well beyond achievements to date”* (AECOM 2013, p. 76).

A major recent development was the recent decision in January 2014 by the European Parliament to modernize European public procurement rules by recommending the use of electronic tools like BIM. *“The adoption of the directive, officially called the European Union Public Procurement Directive (EUPPD) means that all the 28 European Member States may encourage, specify or mandate the use of BIM for publicly funded construction and building projects in the European Union by 2016. The UK, Netherlands, Denmark, Finland and Norway already require the use of BIM for publicly funded building projects.”* (Autodesk 2014, p.1). This clearly has potentially significant ramifications for BIM implementation in the region.

3. Literature Review – BIM Implementation – Regional Trends

3.1. United States

The United States have long been a global leader in BIM development and implementation in the construction industry (Wong et al. 2009). In the United States the US General Services Administration (GSA) has pioneered the implementation of BIM on public projects. The GSA is responsible for the construction and operation of all federal facilities in the US. In 2003 they established a national 3D-4D-BIM program through its Public Buildings Service (PBS) Office. In 2007 they mandated the use of BIM for spatial program validation on all of its projects (Khemlani 2012). They have also developed a range of guidelines and standards that includes a National BIM Standard that is internationally recognized. The GSA are clear leaders in promoting BIM adoption initiatives (CIBER 2012). As a major public sector client with approximately 8700 buildings and over 300 million feet of space across the United States this program has had a tremendous influence on BIM adoption thus demonstrating the importance of major client and government leadership for the industry (Building Smart Australasia 2012).

3.2. United Kingdom

In the United Kingdom the government has introduced a BIM implementation strategy for the UK construction industry that is considered by many to be the most ambitious and advanced centrally driven BIM implementation program in the world (HM Government 2012). The objective is to transform the UK industry into a global BIM leader in a relatively short space of time (Withers 2012). The UK Government Construction Strategy was instigated in 2011 with the intention to require BIM on all of government projects by 2016 through a 5 year staged implementation plan. BIM is seen as central to the government’s objective in achieving a 20% saving in procurement costs (Cabinet Office 2011). This strategy has had a dramatic impact on the UK construction industry as firms face the reality of developing the necessary technological capabilities to meet these requirements. The UK government has established a BIM Task Group to assist both the public sector clients and the private sector supply chain in reengineering their work practices to facilitate BIM delivery (McGraw Hill 2014).

3.3. Scandinavian Region

The Scandinavian region is also a global leader in BIM adoption and implementation. Norway, Denmark and Finland embraced the ArchiCAD software early and were amongst the first countries to adopt model-based design and advocate for interoperability and open standards and have been integral to the development of Industry Foundation Classes (IFCs) and another interoperability initiatives. Khemlani (2012) contends that prefabrication is an important element of construction in this region and that the model based BIM technology is ideally suited for this construction methodology. The various governments in this region also provide considerable support and incentives for the development and implementation of BIM technology. The Finnish Government have invested heavily in IT research in the construction industry since the 1970s (Granholm 2011). They recently released a Universal BIM Guide for the industry which is being heavily supported. The Finnish public sector is the key driver in BIM adoption with Senate Properties, a major government entity responsible for managing the country's property assets, leading the way and requiring BIM modeling that is IFC compliant since 2007 (BuildingSmart Australasia 2012).

The Danish government is a strong supporter of BIM and invests heavily in research and development (Granholm 2011). Danish government clients such as the Palaces & Properties Agency, the Danish University Property Agency and the Defence Construction Service all require the use of BIM on their projects (BCA 2012). Denmark is also leading the development of a new BIM classification standard by Cuneco, a centre for productivity in construction. The objective is to establish this standard for not only Denmark but for the European Union region (and potentially for global use). This new BIM classification standard is very important for the European Union and there has been worldwide interest in its development (PR Web 2013). In Norway BIM implementation is led by Statsbygg – a firm responsible for construction, management and development of government facilities. They have used BIM for their projects since 2007 and have required IFC compliant BIM since 2010 (BuildingSmart Australasia 2012).

3.4. Australia

In Australia BIM use in the construction industry is not currently widespread and there has not been any government mandates to use BIM on projects of any note. But the past five years has seen interest in BIM adoption intensifying as a result of a number of initiatives to engage and inform project stakeholders about the potential productivity gains and gaining competitive advantage (CIBER 2012). These initiatives include the development of Australasian BIM guides such as the 'National BIM Guide' by the National Specification (NATSPEC), 'National Guidelines for Digital Modelling' by the Corporate Research Centre for Construction Innovation (CRC-CI), the 'Australian and New Zealand Revit Standards' (ANZRS) and the BIM-MEPAUS guidelines and models. The 'buildingSmart' organisation (previously called the International Alliance for Interoperability) continues to play a major leading role in BIM development and implementation in Australia that includes establishing an 'Open BIM Alliance of Australia' that involves an alliance with a number of software vendors to promote the concept of 'Open BIM' (CIBER 2012).

3.5. Singapore

The Chinese industry is in the early stages of BIM adoption. A survey undertaken by the China Singapore is also emerging as a world leader in BIM implementation. The Singapore Building and Construction Authority (BCA) have developed a strategy to have BIM widely implemented on public projects by 2015 (Granholm 2011). The government has also established a Construction Productivity and Capability Fund (CPCF) of S\$250 million with BIM a key target. In 2000 the Construction and Real Estate Network (CORENET) program was established as a strategic initiative to drive transformation in the industry through the use of information

technology. CORENET provides the infrastructure for the exchange of information amongst all project participants. The CORENET e-Plan Check system for development applications is a further initiative to encourage the industry to use BIM. The system enables architects and engineers to check their BIM designed buildings for regulatory compliance through an online 'gateway'. Singapore has adopted the Industry Foundation Classes (IFC) as the standard for BIM implementation (Building Smart 2012).

3.6. China

The Chinese industry is in the early stages of BIM adoption. A survey undertaken by the China Construction Industry Association in 2012 found that less than 15% of 388 surveyed Chinese construction companies used BIM (McGraw Hill 2014). McGraw Hill also undertook industry interviews with leading professionals to gain an insight into BIM implementation in China. They found that contractors were adopting the technology at a faster rate than design professionals. BIM was considered by designers as merely being 'additional work' within a fixed fee and so lacked incentives. They also found that the Chinese industry had structural barriers such as difficulties with changing traditional methods and that on many projects the Chinese law requires the design and construction stages to be separated with contractors not involved in the design stage. This inhibits the use of collaborative BIM approaches.

Nevertheless, a China BIM Union was formed in 2013 as part of the China Industry Technology Innovation Strategic Alliance by the Ministry of Science and Technology. The development of BIM standards is occurring and a draft of the Chinese National Standard 'Unified Standard for BIM Application' has been completed and issued for comment (Natspec 2014).

4. Research Methodology

The literature review revealed that many countries are leading the way with BIM implementation. Accordingly the research methodology adopted for the next phase of this study was to undertake an analysis of the key factors in these countries that facilitate successful BIM implementation. The purpose of the investigation was to determine best practice and innovative approaches being used around the globe that can be used by all. The following provides an overview of the main findings of this research.

5. Research Results – Best Practice & Innovative Approaches to BIM implementation.

5.1. Government & Industry Leadership

The research revealed that the most critical factor for successful BIM implementation is national leadership and coordination to maximize efficiencies and avoid the many problems created by piecemeal and disjointed approaches. This leadership should primarily be driven by government entities but needs the support of and collaboration with major industry players such as major private sector clients, contractors and industry/professional associations. Given the global nature of construction activity there is also the need for global leadership to facilitate the transportability of BIM implementation across the world. The recent European Union Public Procurement Directive (EUPPD) by the European Parliament for the 28 European Union member countries to encourage, specify or mandate the use of BIM for their publicly funded projects is a prime example of this high level leadership (Autodesk 2014). Autodesk also contends that this will boost the European Union construction industry's global competitiveness in securing international construction contracts. These global initiatives also need to be supported by international BIM standards and protocols that are 'borderless' and can be applied in all countries as applicable. There is much duplication of effort in BIM development across the world and there is much to be gained by global leadership in coordinating this and bringing it all together for mutual benefit.

5.2. The Business Case and Competitive Advantage

Competitive advantage also provides a significant trigger for BIM implementation. The construction industry is characterized by firms who adopt a ‘wait and see’ approach and are averse to investing in leading the way with new practices. However, as firms increasingly see their competitors gaining competitive advantage through their BIM expertise the greater the incentive to jump on board. This doesn’t apply to just national considerations. It is clear that firms will increasingly struggle to secure work on international projects if they don’t have BIM capabilities. This competitive advantage has global implications. Firms need to be globally competitive even if they don’t work on international works as they will increasingly be competing against international firms with these capabilities on their domestic projects.

The business case for all players in the construction industry needs to be a key consideration. If the business value and the return on investment (RIO) of BIM implementation cannot be adequately communicated then this will create a barrier. This is the bottom line for business. Currently BIM implementation is still inhibited by firms that have cynical and negative views on the value of investing in the necessary BIM technology and training largely due to the difficulties in articulating the business case for these firms. The McGraw Hill (2014) report on the business value of BIM in the major global construction markets is a good example of what is needed to communicate the benefits to firms. Their major survey of contracting organisations in North America, Brazil, Europe and the Asia Pacific found that 75% of firms had a positive return on investment in their BIM program with reduced errors and omissions, less rework and lower construction costs cited as the key benefits. The firms also predicted that the percentage of their work that involves BIM will increase by 50% over the next 2 years giving a clear indication that investment in BIM is essential for firms – otherwise they will be left behind with potentially disastrous business consequences.

5.3. National & Global Standards

Consistent national and global standards are necessary to achieve the efficiencies envisioned by this technology. It is nonsensical for there to be a large range of different systems and piecemeal approaches to BIM development. Global leadership can help to ensure that collaboration occurs on a national and global scale. Clearly, if BIM is to be the future of international projects, then common standards need to be adopted. Key to this will be the use of Industry Foundation Classes (IFCs), the vendor neutral format which allows models to be worked on independently of specific software. There continues to be much confusion about this technology (NBS 2013).

5.4. BIM Protocols & Contracts

Legal and contractual issues with the use of BIM models are another critical consideration. The uncertainty of legal liability is due to the large number of project participants contributing to the BIM model and/or relying on the accuracy and quality of the information in the model. A range of initiatives are being developed in various countries to address this issue but there is still a long way to go. The American Institute of Architects (AIA) 9 has developed a BIM protocol document (Conditions of Contract) to engage with BIM that is widely cited as a good legal model. This protocol establishes a binding relationship between the parties for agreement on the key issues: protocols, level of model development and model elements (CIBER 2012). The US National Institute of Building Sciences (NIBS) have investigated the establishment of project based liability insurance cover to reduce the risks associated with an integrated approach to design and construction. Issues relating to Intellectual Property (IP) rights and data ownership also need to

be more effectively addressed. Many firms are loathe to share their databases and information that they view as their own intellectual property that provides them with competitive advantage. An example is the cost data bases of project cost management consultants. There is also a need for appropriate audit and risk management control mechanisms.

5.5. Project Procurement Systems - Integrated Project Delivery

The development of project procurement systems based on Integrated Project Delivery (IPD) systems are widely seen as essential for the effective implementation of BIM and all the benefits that it can potentially bring to the project (Building Smart 2012, McGraw Hill 2014, CIBER 2012). The American Institute of Architects and McGraw Hill developed the following working definition of Integrated Project Delivery that continues to be widely used. . *'Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction. IPD principles can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basic triad of owner, architect, and contractor. IPD uses business structures, practices, and processes to collaboratively use the talents and insights of all participants in the design, construction and fabrication process. Beginning when the project is first conceptualized, the integrated process continues throughout the full life cycle of the facilities'*. (AIA 2007, p. 1)

5.6. Quality of the Model

These legal issues directly relate to the quality and accuracy of the BIM model. BIM models require the input of vast amounts of complex information from a wide range of project participants. The quality, comprehensiveness and accuracy of this information are crucial to the successful use of the model. Research has shown that one of the major concerns with BIM models is the quality of the model (Smith 2013) – if parties don't trust the information in the model then it has obvious consequences. For example Smith (2013) found that quantity surveyors/cost planners commonly use traditional quantification methods rather than the automated quantities capabilities of BIM models due to concerns over the accuracy of the information in the model. BIM model quality requires clients to be prepared to invest in the necessary resources to achieve the required quality levels but this can be difficult with clients who focus on saving 'up front' costs in the design development stages.

5.7. BIM Maturity Models & BIM Engagement Index

BIM expertise correlates directly with experience and BIM Implementation (McGraw Hill 2014). BIM maturity models and engagement indexes are now being used to assess BIM capabilities. Kassem et al. (2013) contend that most models are focused on the individual organization but that there is a need for country-wide maturity/engagement scales and models. BIM adoption surveys can form the starting point for country-wide measures of BIM maturity. Kassem et al. cited BIM adoption surveys carried out in Australia, the United Kingdom and the United States as examples of metrics that can be utilised in country BIM maturity models. BIM Education, Training & Research

5.8. BIM Training & Education

BIM education, training and research are essential to drive not only implementation but also the evolution of the industry. BIM education is required at tertiary level so that graduates entering the industry have the necessary BIM knowledgeable and capabilities. Natspec (2013, p.1) contend that *"an industry reluctance to change, a 'wait and see' approach and a shortage of experienced/educated BIM practitioners/technicians/educators is slowing the inevitable uptake of*

BIM in the AEC industry. It is clear that tertiary education institutions, with the support of government and industry, need to fully incorporate BIM education into their curricula, to provide the AEC industry with the 'BIM-ready' graduates required for the collaborative BIM working environments to which they will be part of in the future". They undertook an international study of tertiary BIM education and found that current BIM education tends to focus on the use of particular BIM software but that there is a pressing need for education in open BIM concepts, BIM management and working in collaborative BIM environments.

6. Conclusion

The innovative approaches to BIM implementation being used by leaders in the field (government, public/private sector clients and firms) are perhaps too far ahead for many in the industry who have yet to venture down this path in any meaningful form. For these firms lagging behind, fundamental shifts in their business practices are required and this all takes time to develop. However, the competitive advantages already being realised by their competitors are likely to provide more of a catalyst for change than anything else. The longer firms delay their entry into the BIM world the further other firms with these capabilities will progress and add to their competitive advantage. The strategies taken by leading firms to embrace these technological tools and adapt their business practices accordingly should provide considerable inspiration and guidance for others.

Given the globalization of construction activity where international boundaries/barriers are increasingly being removed firms in the construction industry are going to increasingly be competing for work not only against their local competitors with better BIM capabilities but also international competitors who may well bring highly developed BIM capabilities and expertise to the bidding table. The strategic benefits of developing expertise in BIM implementation are very clear in a global market that remains dominated by firms with limited or no capabilities in the field.

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