

# **The Importance of Integrating Cost Management with Building Information Modeling (BIM)**

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## **Abstract:**

The UK construction industry has been branded as an inefficient, fragmented and non-value delivering industry by prominent critics such as Michael Latham and Sir. John Egan; both have insisted on the need to change the way the industry delivers and manages assets through integrated project processes. Sir. John Egan specifically highlighted the need for significant reduction in project time and cost. As a result, for the last few years the main emphasis within the construction industry is on integrating various project processes by using the integrated approach and enabling technologies that bring all the stakeholders in a close relationship for achieving greater success. One of the most critical project processes is the cost management that involves cost estimating, control of expenditure and cost advice on cash flow and payments. Furthermore, Building Information Modeling (BIM) has emerged as a very powerful approach and set of information technologies that allows the project stakeholders to work collaboratively on highly technical and comprehensive models using parametric design components and visualize design in 3D. The UK government has made the delivery of public procured projects through BIM mandatory from 2016. Thus, it has become critical to investigate the prospects of cost management practice in this context and determination of how BIM can help in its improvement.

The aim of this paper is to examine the importance of BIM in the UK construction sector with a specific focus on cost management through a state-of-the-art review of literature in order to highlight the significance of BIM for potential improvements in area of cost management.

## **Keywords:**

Building Information Modeling, Cost Estimating, Cost Management

## **1.0 Introduction**

The UK construction industry is largely guided by recommendations made by government industry initiatives that identified the need for reducing waste and adding value to the project through streamlining the design and production processes (Egan, 1998, 2002; Latham, 1994). Taking inspiration from their work, this study focuses on the identification of issues and challenges in current cost management practice in the UK construction industry because it is one of the most critical process in construction projects as mentioned by Hanid, Siriwardena, & Koskela (2011) and seeks the possibility of improvement by streamlining the cost management with other project processes through integration with BIM.

BIM is making significant impact on the UK construction industry (Eastman, Teicholz, Sacks, & Liston, 2011) and this technological push is driven by the UK government being the major public construction client (Office, 2011; Withers, 2011). However, while the designers and constructors have been embracing BIM, cost consultants on the other hand are showing resistance (NBS, 2014; Wu, Wood, Ginige, & Jong, 2014). That is one of the reasons why the cost management practice and the adoption of BIM stand far apart.

This paper is focused on determining the importance of integrating cost management and BIM to highlight the benefits and identify potential challenges. The research method adopted for this research is a comprehensive literature review of cost management in construction and BIM. The first part comprises the literature review of cost management and the second part contains a brief introduction of BIM and its principles proceeding to the third part that focuses on applicability of BIM in area of construction cost management.

## **2.0 Cost Management in Construction**

Ashworth (2010, p. 434) has defined cost management in the construction industry as “a process of planning, estimating, co-ordination, control and reporting of all cost-related aspects from project initiation up to the time of an asset’s eventual disposal”. It has to account all types of costs that are incurred by the facility over its lifetime as suggested by Ballard (2008).

There are a number of cost accounting concepts that guide cost managers such as Full Absorption, Activity-Based Accounting, Constraint-Based Accounting, Throughput Accounting, Target Accounting, Lean Cost Accounting, Inter-Organisation Cost Management, Whole-Life Costing, Value Management, Risk Management (Agndal & Nilsson, 2009; Burtonshaw-Gunn, 2009; Cartlidge, 2009; Dallas, 2006; Hanid, Koskela, & Siriwardena, 2010a; Kelly, Male, & Graham, 2004; Kishk et al., 2003; Potts, 2008; Wübbenhorst, 1986). While, all of these approaches focus on reducing and controlling project costs but the traditional concepts and practice ignore the notion of value and process improvement as discussed by Fine (1974) and Hanid et al. (2010a). Therefore, the current practice has failed in achieving these targets. Literature reveals a number of issues and challenges faced by cost managers and they are discussed in succeeding section.

## **3.0 Challenges in Construction Cost Management**

The issues and challenges faced by the cost managers include disruptions in the process, design liability, duration of project, lack of collaboration and inadequate design reviewing, isolated decision making, use of traditional cost accounting methods and lack of automated processes (Ashworth, 2010; Hastak, 1998; Kern & Formoso, 2004). Along with these there is lack of knowledge, limited and wrong understanding and practice of cost management techniques (Dallas, 2006; Hanid et al., 2011). In addition, these issues are mainly related to the state of technology, knowledge, quality of data, communication, collaboration of project participants and coordination of activities.

### ***3.1 Technology Issues***

IT has made limited impact on the construction cost management (Cartlidge, 2006; Fazenda, 2011; Smith & Tardif, 2009). Computer-Aided Design (CAD) has been mainly used for drafting, modeling and measurement purposes (Olatunji et al., 2010) and 2D drawings only provide the geometric data (Eastman et al., 2011) that has no visualization and limits the project understanding. Due to non-interoperable isolated software and lack of automated processes, there is a large proportion of manual, labour and time intensive work involved such as measurements, data entry, cost calculations and documentation. The resulting physical and mental overload has a negative impact on the cost manager's performance (Akintoye & Fitzgerald, 2000; Eastman et al., 2011).

Akintoye & Fitzgerald (2000) identified inability to respond to the variations, lack of cost data review and use of basic isolated systems are major reasons for low reliability of estimates. According to Eastman et al. (2011), system incompatibility issues and loss of data has cost implications. Also, the current computer programs are inadequate, e.g. they calculate even more risk cost than the traditional allowance of 5% (Potts, 2008).

### ***3.2 Knowledge and Understanding***

The knowledge and experience of the cost manager plays a vital role in the determination of project cost, understanding project specific needs, making assumptions and choice of appropriate costing technique to be deployed (Akintoye & Fitzgerald, 2000; Eastman et al., 2011; Hastak, 1998). Cost managers aim to make cost estimating and monitoring and control processes accurate but their knowledge and understanding acts as a barrier by limiting their opportunities that can be availed by using alternatives techniques and methods.

Furthermore, detailed costing techniques are not used because of the unfamiliarity and unavailability of required detail of design information, instead cost managers rely upon their experience by making assumptions and adopting the solutions that makes more sense to themselves without consulting rest of the project team that can adversely effects the value and performance (Akintoye & Fitzgerald, 2000). Deliberate production of wrong estimates is also common due to fierce competition and lowest bid contract awards (Akintoye & Fitzgerald, 2000; Hanid, Koskela, & Siriwardena, 2010b). Another bad practice is "production of socially acceptable estimates" because detailed and pricier estimates drive the clients away as stated by Skitmore & Wilcock (1994). Other factors that affect how cost manager use their knowledge include insufficient time allowed and physical and mental work overload (Eastman et al., 2011; Jackson, 2002).

### ***3.3 Use of Traditional Techniques***

The main focus of the traditional cost accounting techniques is on the initial cost that is viewed in relation to product instead of the function which adversely effects the project value proposition (Ashworth & Hogg, 2007; Burtonshaw-Gunn, 2009; Cartlidge, 2009; Dallas, 2006; Hanid et al., 2010a). Akintoye & Fitzgerald (2000) state that these methods bring inaccuracy and uncertainty in the cost estimates.

Four estimating methods are commonly used in construction, namely functional, size related, elemental costs analysis and the unit rates method (Potts, 2008). These methods focus on costing the finished elements and establish budgets. The use of pre-defined budgets as a cost control mechanism limits the opportunities for cost reduction or value enhancing and results in cost dictating the design (Hanid et al., 2011). Wrong interpretation of costing techniques also has a negative impact on the overall cost management process, e.g. Dallas (2006) states that value management is practiced as a cost cutting tool and the value perspective is completely ignored.

While modern clients prefer better value (Kashiwagi & Savicky, 2003), their value perspective is mostly ignored (McNair, Polutnik, & Silvi, 2001) because the conventional methods cannot serve that purpose. The detailed methods that tend to deliver value are not deployed because of unfamiliarity and lack of technological support (Akintoye & Fitzgerald, 2000).

### ***3.4 Quality of Data***

The project scope often has missing information issues causing cost uncertainty (Akintoye & Fitzgerald, 2000). Estimates are produced using historical data of a similar project obtained from a cost database like BCIS that is adjusted to the current market rates (Doloi, 2011; Potts, 2008). Missing design information and elements are filled in by the assumptions made by the cost manager that leads to cost miscalculation. The historical data has inherent issues such as reliability, incomplete information, design faults and is generally aimed at achieving the expected cost (Elfving, Tommelein, & Ballard, 2005; Hanid et al., 2011). Moreover, during construction there is limited project progress data is available, therefore manual processing is required for cost monitoring and control. The lack of standardized mechanism for documentation transmission and recording is a critical reason for data loss resulting in increased cost as stated by Eastman et al. (2011). Therefore the quality of data and its management is a vital to successful cost management of construction project.

### ***3.5 Communication***

Poor communication and feedback systems have been identified in the current cost management practice (Akintoye & Fitzgerald, 2000). The lack of communication and data sharing is result of fierce competition, lack of trust, selfishness, short term relationship and use of isolated systems by the firms, ultimately resulting in the increased project cost as discussed by Eastman et al. (2011). The lack of the availability of required information can lead to ineffective decision making. Cost managers obtain up to date data by information requests and going through extensive paperwork. This leads to inefficient and delayed cost accounting that does not correspond to actual project progress. Information and Communication Technology (ICT) enables the project team to share and disseminate project information (Cartlidge, 2006) but the low level of collaboration amongst participants indicates the lack of interest in developing communication and information sharing.

### ***3.6 Collaboration of Participants***

Lack of coordination and collaboration among the construction project participants has been highlighted by Latham (1994) and Potts (2008). It has a negative impact on the project cost and cost management practice because each organisation is focused

on making their own profit instead of overall project benefit that ultimately leads to value loss as discussed by Hanid et al. (2011). The collaborative working has a lot of potential for cost reduction. Each organisation has an impact on project cost and the sum of these is called Inter-Organisational Cost (IOC) (Kulmala, Paranko, & Uusi-Rauva, 2002). In order to effectively control project cost, it is vital to minimize IOC and the mechanism is called Inter-Organizational Cost Management (IOCM) (Agndal & Nilsson, 2009). IOCM is a joint process focused on cost reduction through formal collaborative relationship between project participant organisations (Cooper & Slagmulder, 2004). IOCM requires mutual trust, information sharing, long term partnering, open book accounting and profit sharing (Kulmala et al., 2002; Zaghoul & Hartman, 2003). The firms need to proactively extend the best practice across the supply chain for collective cost reduction. Hanid et al. (2011) have highlighted the need for deployment of collaborative approaches such as Just-in-Time (JIT), Total Quality Management (TQM) and open book accounting for improving IOCM. However, they also indicate that the negative behaviour of clients and contractors are a major obstacle that prevent the collaboration and these behaviours are linked to the nature of the construction industry and bad practices focused on winning the workload and securing their profit/ saving.

### ***3.7 Coordination***

The lack of coordination between project processes such as cost management, design and construction cause difficulty in cost estimating and monitoring and controlling. Furthermore, the lack of coordination between cost management and production process results in value loss and inconsistent cost accounting (Hanid et al., 2011). As a result, construction projects go over budget and payment disputes arise (Doloi, 2011; Kashiwagi & Savicky, 2003). This is partly due to isolated location of information from schedule of payments, production plans and feedback from cost control process (Kern & Formoso, 2004). The lack of coordinated cost management causes delays, conflicts, ambiguities and inaccuracies in cash flow management. Other problems resulting from isolation include delays and disruption in the process or plan, facility defects and lack of continuation of payments, project duration, inaccurate measurement of works, variations in work or material and cost discrepancies (Hwee & Tiong, 2002; Thompson, 1976). Therefore, improvement in coordination is vital for successful cost management.

The above discussion on the issues that are currently being experienced by the cost management practice provide an insight and highlight the need for immediate action. The next section contains discussion on BIM and its applicability in the area of cost management.

### **4.0 Building Information Modeling (BIM)**

With growing BIM has emerged as a highly advance and integrated approach coupled with very sophisticated technology to tackle the chronic problems of the construction industry such as isolated operations of stakeholders, incompatibility among systems, limited use of ICT and overwhelmingly manual processes that are responsible for waste, cost overruns and loss of value (Eastman et al., 2011; Olatunji, Sher, & Ogunsemi, 2010). The UK construction industry is going through a major transition towards adopting BIM (Office, 2011; Wu et al., 2014). There are high expectations

associated with BIM adoption such as increased productivity and collaboration (Miettinen & Paavola, 2014).

BIM is essentially an approach and a set of processes and ICT that allows the project stakeholders to collaborate using 3D design and information models that contain parametric objects and associated geometric and non-geometric information (Eastman et al., 2011; London, Singh, Taylor, Gu, & Brankovic, 2008; NBIMS, 2011; Succar, 2009). Miettinen & Paavola (2014) it also acts as a tool and a repository for handling and storing building design data and all the related information that can be used throughout the building's life-cycle.

#### ***4.1 Basic Principles of BIM***

BIM has a great potential for influencing the people, process, technology and information in the construction industry through its primary principles that are Interoperability, Parametric Objects and 3D Modeling complemented by highly advanced Information Management System enabling multi-disciplinary collaboration (Eastman et al., 2011; London et al., 2008; NBIMS, 2011; Popov, Juocevicius, Migilinskas, Ustinovichius, & Mikalauskas, 2010; Succar, 2009; Wu et al., 2014).

- ***Interoperability***

Interoperability has been defined as the “ability to exchange data between applications, which smoothes workflows and sometimes facilitates their automation” (Eastman et al., 2011, p. 99). BIM provides an interoperable platform that allows stakeholders from various trade backgrounds to collaborate and exchange data (Steel & Drogemuller, 2009).

- ***Parametric Objects***

Parametric objects are design components that feature the geometric & non-geometric information and rules for creating relationships between these intelligent objects within the building's model (Eastman et al., 2011; NBS, 2011). These intelligent objects can be attributed cost and scheduling information that can be used by the cost managers, they also enable constructors to manipulate building design to assess functionality and behaviour of the facility (Sacks, Koskela, Dave, & Owen, 2010).

- ***3D Modeling***

BIM enables representation and creation of building design in 3D modeling format that is the digital representation of physical and functional features of the facility (Eastman et al., 2011; NBS, 2011). Moreover, stakeholders can view the virtual model of the building and components for making assessments such as design verification (Eastman et al., 2011).

#### ***4.2 Information Management in BIM***

BIM has the capability to store geometric and non-geometric project data that can be shared and modified (Eastman et al., 2011; Sacks et al., 2010). BIM provides the constructors with the ability to effectively communicate and share information with the project team including professional, operatives and the client (Eadie, Odeyinka, Browne, McKeown, & Yohanis, 2013; Eastman et al., 2011; Miettinen & Paavola, 2014). The work of various disciplines such as designers, engineers, builders and cost

etc. is brought together to by a centralized BIM model (Thurairajah & Goucher, 2013). It also acts as an information repository and all the project development information from all disciplines can be stored and accessed at any time (Meadati, 2009; Shafiq, Matthews, & Lockley, 2013). Shafiq et al. (2013) suggests that the information management feature of BIM is an important feature for promoting interdisciplinary collaboration. The information in the model can be accessed by the project team to obtain relevant data. There are two modes of data handling in BIM; exchange (*importing or exporting of unstructured and incomputable data*) and interchange (*importing or exporting of structured and computable data*) as stated by Succar (2009). The introduction of IFC (Industry Foundation Classes) file format have helped in overcoming compatibility between different BIM software packages (Eastman et al., 2011; Steel & Drogemuller, 2009).

## **5.0 Implementation of BIM in the UK Construction Industry**

The UK construction industry is following a global trend of implementing BIM and the government as a major construction client has made a commitment to reduce the whole life cost of construction projects by up to 20%, through the Government Construction Strategy launched in 2011, by calling for more integration, standardisation and lean working. A key part of this strategy is the use of collaborative BIM, which has been mandated on all centrally procured public projects by 2016 (Office, 2011; Thurairajah & Goucher, 2013; Wu et al., 2014). This is acting as a major driver for implementing BIM and transforming the UK construction industry (Eadie et al., 2013). The government's demand is currently limited to implementing Level 2 BIM with no obligation to include 4D scheduling and 5D cost data in the model (Thurairajah & Goucher, 2013).

BIM has received a warm welcome in the UK construction industry and academia and there are high hopes for its potential in transforming the traditional practices in the industry. However, NBS (2013, 2014) has reported that designers and constructors have made progress with BIM adoption while on the other hand cost managers are still resisting it. If this reluctance continues, it is feared that the cost management practice may fall behind other trades in adopting BIM (Wu et al., 2014). Therefore, it is critical to highlight the potential benefits and improvements that BIM can bring to cost management and to identify the barriers that prevent the cost managers from adopting BIM.

## **6.0 Benefits of Integrating BIM and Cost Management**

The basic principles of BIM; 3D modeling, interoperability, parametric objects and advance information management features, hold a lot of potential for improving the state of cost management practice by resolving problems identified in the traditional practice, as presented previously. The following discussion proceeds to establish importance of integrating cost management with BIM in relation to addressing the issues identified with the traditional practice of cost management.

### ***6.1 Technological Support***

BIM offers highly sophisticated technological platform that includes 3D models consisting elements that have both geometric and non-geometric information associated with it (Eastman et al., 2011). Another key benefit is that the model has the

ability to integrate various information and design models corresponding to various trades that can be simultaneously operated and the information exchange between the models supports quick access and updating. Any changes in the model are recorded and immediately updated. Cost managers can benefit from these features for improved processes.

BIM-based cost estimation can improve overall cost reliability and that is one of the main drivers for its adoption (Eastman et al., 2011). They further state that the process is not 100% automatic as there is still need for professional analysis and input to go into the model first. Cost estimating feature is built into the BIM system, information can be extracted at any required stage and updated automatically if any change is made to the model (Azhar, Hein, & Sketo, 2008). The cost schedules such as Bill of Quantities (BOQ) and the cost plans can be automatically and speedily generated according to measurement rules and cost can be associated like cost to buy, tender, replace or life-cycle cost (Aouad, Lee, & Wu, 2007).

Accuracy of estimates is a serious issue, hence built-in estimation features in BIM software can significantly improve the accuracy of cost the estimates (Nassar, 2010). Projects can be modelled from the concept stage using the parametric objects from the library of previously completed projects (Eadie et al., 2013). This in-turn will enables BIM-based estimation (Wu et al., 2014). Also, new elements can be added to the model with progress in design development thus interim estimates can be easily extracted for function and cost evaluation (Eastman et al., 2011).

Quantities for BOQ can be readily extracted at any stage for producing estimate at that stage as stated by Davidson (2009). Automatic quantity take offs feature of BIM can improve the state of accuracy and time consumption that can be directed towards value enhancing activities (Barker, 2011; Davidson, 2009; Eastman, Teicholz, Sacks, & Liston, 2008; Popov et al., 2010). Detailed cost plans can also be generated far quicker than the traditionally manual methods. 4D project scheduling and 5D Cost libraries can be linked to the BIM model for generating detail cost plan (Thurairajah & Goucher, 2013).

As the estimating information is available, any subsequent process like cost and financial reporting and monitoring processes that rely on this information can also be improved in terms of speed and accurate. The speedy, accurate and detailed information access BIM enables cost managers to compare alternative design solutions for determining better value for the client. However, although BIM makes a lot of time and labour intensive tasks automated, there is still the need for professional input required for making assumptions and assessments.

## ***6.2 Support for Enhanced Knowledge and Understanding of Project and Estimating Techniques***

Due to lack of semantic information and visualization in 2D drawings the project understanding is limited; therefore cost managers have to make excessive assumptions. Automation of complex costing tasks through BIM based estimation, enables the cost managers to generate and compare alternative plans quickly and invest their time and energy in risk management and capital allowances that have more impact on the value (Thurairajah & Goucher, 2013). Availability of the required semantic data helps in shifting cost focus from the traditional finished product to functional perspective (Dallas, 2006). With BIM visualization support cost managers can develop much better understanding of the project design that will help in avoiding



misinterpretation (Meadati, 2009) and are required to make fewer assumptions (Thurairajah & Goucher, 2013).

Similarly, given these benefits and integration of 4D construction schedules and 5D cost data in the BIM, cost management can be implemented in-line with lean principles (Sacks et al., 2010). They further suggest that there are interactions between BIM and Lean as both of them aim for the reduction of waste and adding value to the project.

Life-cycle Cost Estimating can also be improved because BIM automates complex analysis and calculation to support cost managers as previously the detailed estimating methods were avoided (Eastman et al., 2011; Thurairajah & Goucher, 2013). Therefore, BIM can help to alleviate the knowledge and understanding related barriers currently effecting the cost management.

### ***6.3 Support for Enhancing Data Quality***

The quality of data used by the traditional cost management methods is one of the major issues. BIM deployment “earlier in the design process will have greater influence on cost” (Eastman et al., 2011, p. 163), which can help to improve the data quality as the project design will be based on the parametric objects that can be linked to the current cost libraries (Eastman et al., 2011; Thurairajah & Goucher, 2013). Additional components can be added to the BIM model as the design develops (Eastman et al., 2011). BIM models contain more detailed information and 3D visualization help cost managers to make fewer assumptions (Meadati, 2009), which that reduces the uncertainty from estimates. The detailed estimates are considered accurate that can be prepared at any project stage due to BIM data support for integration of cost data and data export and interchange.

Although BIM principally attempts to address the data quality issues but it will take some time before the full benefits are achieved, also there have been attempts to address object definition standards that required to identify particular component i.e. IFCs but still the problems exist as various BIM vendors use different standards (Lawrence, Pottinger, Staub-French, & Nepal, 2014).

### ***6.4 Support for Coordination and Integration of Processes***

The studies on cost management indicate isolation and lack of coordination in the process (Jackson, 2002; Thurairajah & Goucher, 2013). BIM provides an integrated and interoperable platform that can help in resolving these issues. The coordination of 3D design, 4D schedule, and cost integrated 5D BIM can bring the coordination required for the cost management decisions as impact of changes to the design can be simulated (Lawrence et al., 2014; Meadati, 2009). This can remove lack of coordination between contractors and sub-contractors as highlighted by Perera, Davis, & Marosszeky (2009) and Ranns & Ranns (2005).

The re-work and unprecedented cost increment that can result from structural or program clashes can be reduced with BIM scenario simulation, improving the coordination of scheduling and material supplies etc. In addition it also encourages the use of whole-life costing as the facility use, maintenance and decommissioning can be analysed (Eadie et al., 2013). They also found that clash detection feature of BIM is one of the main driver for its acceptance in the UK construction industry. Another key benefit of the improved coordination and integrated systems is significant time saving as reported by Azhar et al. (2008).

BIM provides opportunity to the cost managers to adopt appropriate production plans, undertake value engineer, forecast cost layout and financial commitments by integration of project process and better coordinated activities. Therefore BIM approach cost managers are in a much better position to forecast, monitor and control project costs.

### ***6.5 Collaboration for Cost Management***

Latham and Egan emphasised on the collaborative working and building trust among the stakeholders for streamlining the processes and eliminating waste (Egan, 1998, 2002; Latham, 1994). Thuraiajah & Goucher (2013) has stated that collaborative working is one of the most popular advantage of BIM in construction projects. BIM provides a centralised medium for sharing and storing project information (Eastman et al., 2011). As there is a number of organisations involved in a project, all the supply chain members need to become involved for streamlining the processes (Aouad et al., 2007; Eastman et al., 2011). Eastman et al. (2011) further argues that Lean can be rigorously implemented through collaborative working resulting in better time and cost performance. There is significant potential that waste from the whole supply chain can be removed. The inaccuracies that are caused by the isolated working can be eliminated as well (Thuraiajah & Goucher, 2013).

Collaboration can encourage participants to help each other to improve the product and processes for reducing the inter-organisational costs. Through BIM support, project participants can perform their role in a much better way and promote collaboration. Cost managers can take advantage of this collaboration and advise on cost impact and improvement opportunities and undertake IOCM for cost reduction. Therefore, BIM-based collaboration has the potential for supporting cost management process and cost reduction/accuracy.

## **7.0 Challenges Preventing BIM and Cost Management Integration**

There is a great potential for improving the cost management practice by integrating it with BIM, but there are certain challenges and barriers that prevent this integration to take place. Cost of BIM implementation, training and legal system creates doubt for the sub-contractors to be involved with BIM (Bingham, 2011). This can potentially leave a large number of project participants outside BIM-based cost management and the full benefit of coordination and collaboration will be difficult to achieve such as IOCM for reducing cost across the supply chain. Similar, training and implementation cost problem has been reported to have limited BIM adoption by the cost management practices (NBS, 2014). In addition, Wu et al. (2014) found that this limited BIM adoption is also due to the substandard models, inconsistencies in design information and data exchange tools and formats that are being used in the practice.

Moreover, there is a gap in BIM measurement process and UK measurement standard rules e.g. New Rules of Measurement (NRM) that present a major challenge for UK cost management practice to bridge the UK measurement standards to BIM model (Wu et al., 2014).

There is a lack of availability of comprehensive software solution that can fully perform cost estimating process that is an integral part of cost management which creates a major barrier for integration with BIM (Wu et al., 2014). Literature also indicates that interoperability issues between different BIM vendor's software

(Lawrence et al., 2014; Meadati, 2009; Thurairajah & Goucher, 2013). These interoperability issues causes loss of data that can lead to cost implication and effect the accuracy and consistency of estimates as discussed before. IFCs standards are considered a universal standard, BIM cost estimating tools e.g. CostX does not effectively support IFC format that effects in quantification process (Wu et al., 2014). This can be improved with development and acceptance of IFCs and wider implementation of BIM (Lawrence et al., 2014).

Meadati (2009) has identified that BIM use is limited to design and early construction stages that means that cost monitoring and control in construction and post-construction phase presents a substantial challenge without proper BIM support. In this scenario the pre-construction cost data will be located in BIM, whereas it is ambiguous that how and where the cost data from later project phases will be stored, and located and also how easy it will be to perform the cost assessments using the information from BIM and other yet un-identified sources.

The lack of knowledge and understanding of BIM among cost managers that is preventing BIM adoption and expanded usability in cost management process (Thurairajah & Goucher, 2013; Wu et al., 2014). There is a significant need for investment by the cost management practices in UK to invest in staff training to alleviate this barrier (NBS, 2014).

There is eminent need to alleviate the barriers identified in the practice, people, technology and information for a smooth transition of the semi-automatic and fragmented cost management practice in the UK construction industry to be fully integrated with BIM and completely become BIM-based.

## **8.0 Conclusion**

This paper has focused on the determination of integrating cost management with BIM for improvement in practice. The literature suggests that although the aim of various techniques both traditional and modern aim towards achieving better value for the client and eliminating waste from the costing process in-line with the broader industry targets set by Latham and Egan. However, the current practice has failed to deliver that.

BIM is seen as a very promising development that holds the potential for improving the practice and achieving the industry targets. BIM provides a comprehensive interoperable platform that enables integration of design, schedules and cost data. The project member can access and operate simultaneously and information within the models can be updated. BIM also effectively adjusts the model in response to any change that provides cost managers with a clear picture for making cost adjustments.

Traditionally cost managers had a limited role and functionality due to confined knowledge, techniques, technology, data and information provisions. Due to these limitations the estimates produced were inaccurate and uncertain. BIM provides support in automation of the key tasks such as measurements and quantification, access to comprehensive and current project information, ability to track changes and clashes, single medium for communication with ability to record and store all information produced. The study finds a lot of potential in eradicating waste from the cost management process like re-works and adding value to the practice by undertaking detailed methods of cost estimation enabled through BIM. Also, in line with the government's commitment, BIM will eventually become an integral part of

the construction industry and the delivery and management of built environment assets.

Therefore, the paper confirms that the integration of cost management with BIM is inevitable. However, the barriers of investment, knowledge, process, standards and interoperability are required to be addressed. Furthermore, the paper also indicates that BIM use should be extended to the construction and post construction phases to realise full benefits of BIM and cost management. There is need for detailed research into the challenges and technological implementation in later project stages. This will also help in establishing concurrent cost monitoring and control that could then be able to manage the wider spectrum of project cost defined by Glenn Ballard (2008) as the relative project costs, which will enable realization of full benefits of BIM and cost management.

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