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Client's Role in Building Disaster Management through Building Information Modelling

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Abstract

The building construction stakeholders need to become more proactively involved in making buildings resilient to a wide range of disaster threats (Bosher, 2013). Clients in particular can play a vital role in the resilience of building disaster (Smart Market 2011). Building Information Modelling (BIM) is seen as a new technology, providing highly accurate information which can help to improve building disaster management. In this article a new conceptual framework will represent the relationship between BIM application benefits and the client organisation maturity levels. This framework will help the clients to fully understand and monitor the BIM benefits in building disaster management.

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Keywords: Client, BIM, Maturity level, Building Disaster management

1. Introduction

Disasters in general are defined as any action which may cause threats to life, well-being, material goods, and environment from processes or technology (Gunes and Kovel, 2000). Disaster reduction or reducing the losses incurred, has become the object of great importance since the evolution in human rights laws and safety regulations. The key action for this mission is to make the right decisions at the right time. The disaster management process needs quick accurate information formulated correctly.

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This information should contain what may happen and what has happened and where, and what resources are available to respond. The responders need plans which may help them to predict disasters and outline the available solutions (Su and Jin, 2009).

It is believed that the higher the accuracy of the information, the more highly effective the solutions. Although higher accuracy of information costs more and is time consuming, the key action is to select the appropriate level of accuracy due the specific case conditions. (Li et al., 2014).

In general, information systems designed for emergency response can provide extremely useful information for better planning and coordination during an ongoing crisis (Filippoupolitis et al., 2009). The use of BIM as one of the information systems for disaster and emergency planning is a concept that has yet to be fully developed. Most of the information for this use is from what emergency responders would like to see available in the future. The BIM would provide critical building information to the responders, which in turn would improve the efficiency of the response and, more importantly, minimize the safety risks. (Penn State, 2012). What is more, a BIM may provide information in advance which may support the proactive behaviour of the responders. BIMs also have potential in facilitating post-disaster damage assessment. For example, in the case of flooding, semantic information stored in BIMs will help in answering questions concerning which elements of electrical wiring have suffered damage, or which walls or wall coverings needs replacing. These are just a few instances of the opportunities offered by BIMs in disaster management. Their use will provide a stepping stone towards developing various intelligent software applications for disaster management (Isikdag, 2010).

Considerable research has stated that as one of the construction stakeholders, clients can stimulate the innovation to achieve crucial BIM benefits such as supporting disaster management. (Gann and Salter, 2000, Harty, 2005, Kulatunga et al., 2011, Manley, 2006, Miller, 2009). Furthermore, BIM implementation has been prevented from being more widely accepted across the construction industry by client fears and lack of full understanding of the BIM benefits as well as the requirements that are needed to gather these benefits (Succar, 2010b).

This paper aims to develop a framework which explains the relationship between the Building Information Modelling (BIM) benefits in disaster management and the desired BIM maturity level from a client's perspective .The paper is organized as follows: Section 1 reviews BIM applications which support disaster management, followed by Section 2 that presents the application benefits. Section 3 presents the application requirements, and Section 4 presents the existing maturity evaluation methods. Section 5 presents the framework. Finally, Section 6 discusses the findings, limitations and future research of the work presented in this paper, and concludes the paper.

2. BIM Applications

The application is defined as the act of applying something to a particular purpose or use (TechTerms, October 12, 2008). The applications of BIM have been used in a good number of large-scale construction projects, for instance in commercial, industrial real estate, and infrastructure sectors (Sebastian & van Berlo, 2010). Different types of BIM applications could be applied in each project life cycle stage. Some applications were used in particular stages, while others extended to different stages. The use of any application will be dependent on what the expected benefits are and the capability of the users (Hardin, 2011). Each application has different types of benefit that may apply to a certain stage in the project life cycle or sustain as a long-term benefit. In addition to that, each application has requirements that the users need to provide to achieve the desired benefits (Eastman, 2011). From the literature it can be seen that there are three main applications which support disaster management, existing condition modelling, site planning, and disaster planning. These applications were investigated in detail to find their benefits in disaster management and what their requirements are to work properly.

3. BIM Application Benefits

The definition of benefit in general is "an outcome of change which is perceived as a positive by stakeholders" (Bradley, 2010). Stanford University's Centre for Integrated Facilities Engineering highlighted that the main benefit of BIM (cited in CRC Construction Innovation ,2007) reduces the un-budget change up to 40%, increases the cost estimation accuracy up to 3%, reduces time taken to generate a cost estimate up to 80%, increases the contract's

value up to 10% and provides up to 7% reduction in the project period. In addition, Holzer (2013) indicated that BIM represents a more accurate way of working. As the processes change, BIM will reduce waste (materials, resources & cost) through improved designs and construction processes (Azhar, 2011).

Clients in particular can achieve worthy benefits on their construction projects by adopting BIM as a process and tool to guide their delivery process to higher quality and performance for a whole building life cycle (Eastman, 2011). BIM changes the methods of design and builds (Yan & Damian, 2008), which leads to reducing the total cost and time as a direct benefit (Love et al., 2013). Y Arayici et al. (2011) concluded that the collaboration among stakeholders will expand the client's organisational boundaries which may lead to increased performance of the project during different stages of the life cycle. BIM can help in creating this new collaborative environment, where all the project stakeholders can sit together and exchange information between themselves in the early stage of the project life cycle. However, the organisation readiness and capability to provide and accept such an environment will have an impact on the expected benefits. This new process of sharing information will provide some direct valuable benefits for the client, specifically full project understanding (Azhar, Khalfan, & Maqsood, 2012; Bryde, Broquetas, & Volm, 2013; Eastman, 2011; Succar, 2009).

Existing condition modelling, site planning, and disaster planning in particular will produce valuable benefits in the disaster management process. Appendix B will explain all these application benefits and requirements in disaster management.

4. BIM Application Requirements:

Each BIM application needs a set of requirements to ensure that it runs perfectly and thus ensure getting the desired benefits from the application (Penn State, 2012). The failure to provide these requirements or provide a part of it will be reflected directly on the benefits of the application (B. Becerik-Gerber, Jazizadeh, Li, & Calis, 2011). The application requirements are not fixed, but rely entirely on the user. For example, the application used by the designer will differ in their aims and purpose from the contractors. For this research, all BIM application requirements will be investigated with respect to the client as the main beneficiary (Mayo, Giel, & Issa, 2012; Penn State, 2012).

5. BIM Maturity Levels:

It has been approved that information systems and technology represent the main factors in supporting BIM (Haron, 2013; Mayo et al., 2012). Therefore, before starting the process of assessing the BIM maturity level, many studies have looked at how other Information Systems (IS) investments are evaluated (Mayo et al., 2012).

There have been quite a number of methods used to evaluate the BIM implementation maturity in recent years. The various maturity models and scoring systems tend to fall into two basic categories (B. Giel & Issa, 2012; Succar, 2010a). The first category is focused on how to evaluate a particular project against BIM implementation. The second category would take the entire organisation as its target to evaluate against BIM implementation..

At this stage a comparison was made between these three models (Succar 2010, Penn State Matrix 2012, and GPIS 2005) in order to select the elements and categories of the maturity matrix. The selection and adoption of each category were made based on the following criteria:

- The frequency of occurrence among the models reviewed.
- The suitability of the category to be used within the context of client organisations.
- The suitability of the category to be used specifically with the context of BIM implementation.

6. Conceptual Framework

After conducting a rigorous "Literature Review", three applications were identified as the main factors for the client organisation being motivated to implement BIM in their internal processes to emphasise the disaster management process. All tangible and intangible benefits were investigated. These benefits were achieved through a BIM application, which it also identified through literature review. These applications will be distributed against the new RIBA project life cycle as shown in appendix A. This distribution will help the client to track their benefits through the project life cycle and examine the entire BIM application requirement through the existing maturity

indicators. By following the steps outlined in the conceptual framework as shown in figure (1), all the BIM application requirements and benefits will be spotted. The next step involves classifying the requirements for each application according to the main maturity matrix components. After this, the classified requirements will be distributed against the maturity levels, which are divided into four levels from level one to level four as shown in table (1). By exploring and knowing the relationship between the requirements and benefits, the researcher was able to distribute benefits through the maturity levels as shown in table (2). This conceptual model explains the relationship between the BIM implementation maturity level and the benefits related with it. It also covers all the benefits in the disaster management process which represent the main tangible and intangible benefits that clients can achieve through implementing BIM in their internal organisational system.

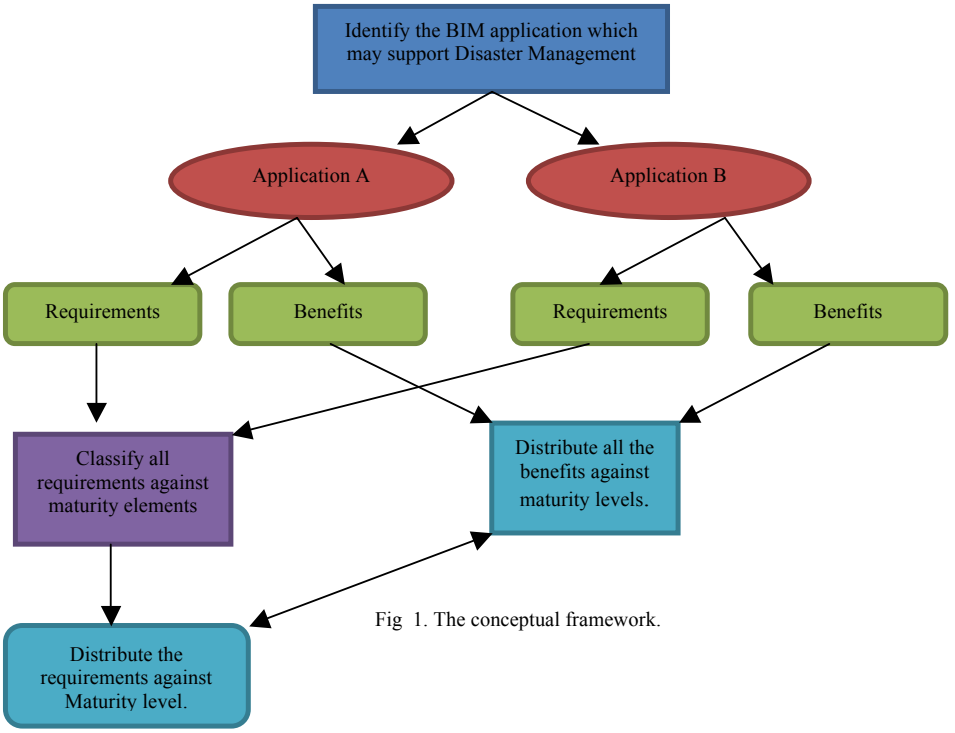


Fig 1. The conceptual framework.

7. Framework Benefits and Contribution

This framework will represent the relationship between the BIM maturity level and BIM application benefits. This relationship was explained through distrusting the BIM application requirements through the BIM maturity level and also explained the expected benefits for each maturity level with respect to certain applications. This article only focuses on how the BIM application can produce benefits in disaster management.

The following expected benefits can be achieved when a client organisation applies this framework in order to examine their ability to achieve all BIM application benefits in disaster management.

- The framework will help the client to formulate a clear vision regarding how to build capacity to ensure the achievement of the desired benefits.
- The disaster management process will gather huge benefits when the client leads the BIM implementation process.
- The framework helps the client to find their actual BIM maturity level and to find out what the expected benefits related with it are.
- The deeper explanation of benefits against BIM maturity level will help the client to select the appropriate maturity level.

Table 1. The distribution of BIM application requirements through maturity levels.

No	BIM Application	Requirements	Accepted Design Benefits Some Construction Benefits Some In-Use Benefits L1	Best Design Benefits Accepted Construction Benefits Some In-Use Benefits L2	Best Design Benefits Best Construction Benefits Accepted In-Use Benefits L3	Best Design Benefits Best Construction Benefits Best In-Use Benefits L4
1	Any Application	• Environment 1. • People 1. • Process 1. • IT system 1.	All the requirements that are needed to gather the level of benefits listed above will be explained here.	All the requirements that are needed to gather the level of benefits listed above will be explained here.	All the requirements that are needed to gather the level of benefits listed above will be explained here.	All the requirements that are needed to gather the level of benefits listed above will be explained here.

Table 2. The distribution of BIM Application benefits through maturity levels.

No	BIM Application	Accepted Design Benefits Some Construction Benefits Some In-Use Benefits L1	Best Design Benefits Accepted Construction Benefits Some In-Use Benefits L2	Best Design Benefits Best Construction Benefits Accepted In-Use Benefits L3	Best Design Benefits Best Construction Benefits Best In-Use Benefits L4
1	Any Application	All the expected benefits at this level will be explained here.	All the expected benefits at this level will be explained here.	All the expected benefits at this level will be explained here.	All the expected benefits at this level will be explained here.

8. Conclusion and Future work.

The authors have presented the new framework which explains the relationship between the BIM maturity level and the benefits related with it. The results of this study are summarised as follows.

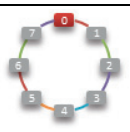
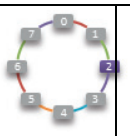
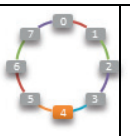
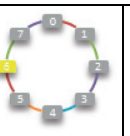
- The authors have developed a methodology for finding all BIM applications which support the disaster management process.
- All the BIM applications requirements and benefits were spotted through the literature review.
- All the existing maturity methods were investigated in order to find the best BIM maturity components which related specifically to the client.
- The authors have suggested a framework which explains the relationship between the BIM maturity level and the benefits which are related to it. Client organisations can use this framework to evaluate their maturity and their benefits. These results provide the opportunity for the client to change the existing BIM implementation plan.

This study has some limitations and opportunities for future studies. Firstly, this paper represents only a conceptual framework, with actual data needing to be collected to validate this framework. Secondly, the focus of this study has been limited to client organisations only. Future studies can examine all the BIM applications though the project life cycle and explain the benefits and requirements for each application.

Acknowledgments

This paper will represent part of the author's work as a PHD student in Salford University, Built Environment School.

Appendix A.

 Stage 0	 Stage 1	 Stage 2	 Stage3	 Stage 4	 Stage 5	 Stage 6	 Stage 7
Appraisal	Design Brief	Concept Design	Design Development	Technical Design	Construction	Handover	In use
		Existing Condition Modelling					
					Site utilization Planning		
							Disaster Planning

Appendix B.

No	Application	Description	Requirements	Benefits	References
1	Existing condition modelling	This application helps the project team to create the 3D model containing the entire external environment which surrounded the proposed project.	• The staff are able to manipulate navigate, and review a 3D model. • Familiarity with Building Information Model authoring tools. • Familiarity of 3D laser scanning tools. • Familiarity of conventional surveying tools and equipment. • Ability to determine what is the optimum level of detail which may able to add "value" to the project. • Ability to select the appropriate software to create the site-linked BIM model.	• Increase the efficiency and accuracy of existing conditions documentation and representation. • Help in future modelling and 3D design coordination. • Provides an accurate representation and visualisation of work that has been put into place. • Real-time quantity verification for accounting cost estimation purposes. • Disaster Planning. • Time Saving Utility Design.	• (John M. Russo, 2012) • (Wang, 2011) • (Arayici and Hamilton, 2005) • (Construction, 2012) • (Penn State, 2012) • (Becerik-Gerber et al., 2012) • (UK BIM Standarded, 2012) • (Smart market Report 2012) • (Reddy, 2012) • (Eastman, 2011)
2	Site analysis	This application can be used to simulate all the existing facilities during different project phases in order to optimise the project construction process.	• The staff are able to manipulate, navigate, and review a 3D model. • Familiarity of local authority's system (GIS, database information). • Suitable software and hardware.	• Enhance the decision making process through provide all the require information that may need it to choose the suitable site for the project. • Decrease costs of all additional work may need it to prepare the site before stat the project. • Increase energy efficiency. • Increase safety	• (X. Zhang, Arayici, Wu, Abbott, & Aouad, 2009) • (Middlebrooks, 2008) • (Wang, 2011) • (Azhar et al., 2011) • (Construction, 2012) • (UK BIM Standarded, 2012) • (Smart market Report 2012) • (Reddy, 2012)

No	Application	Description	Requirements	Benefits	References
					• (Eastman, 2011)
3	Disaster Planning	This application will help the emergency responders to have access to critical building information in the form of a model and information system to minimise the expected threats.	• Suitable software and hardware like Building Automation System (BAS) and Computerized Maintenance Management System (CMMS), this software needs to be connected to the record model Building Automation System (BAS) linked to Record Model. • The staff are able to manipulate navigate, and review a 3D model. • The staffs are able to make appropriate decisions during an emergency.	• Provide real time accurate information about any emergency event for different type of responders like police, fire, and public safety officials. • Improve the effectiveness of emergency response. • Minimize risks to responders.	• (Construction, 2012) • (Penn State, 2012) • (A. A. Becerik-Gerber, Burcin et al., 2012) • (UK BIM Standarded, 2012) • (Smart market Report 2012) • (Reddy, 2012) • (Eastman, 2011) • (Hergunsel, 2011)

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