A study on effectiveness of Building Information Modelling (BIM) on the Malaysian construction industry

S W R Kong¹, L T Lau¹, S Y Wong¹ and D T Phan¹

¹ Department of Civil Engineering, FOSE, University of Nottingham Malaysia, Selangor, Malaysia
Corresponding author: duoc.phan@nottingham.edu.my

Abstract. The introduction of Building Information Modelling (BIM) in Malaysia has been fairly recent and is gaining popularity. Although most literature have been focused on the adoption and application of BIM in Malaysia construction industry, the effectiveness of BIM has not been investigated. This study aims to investigate the influence of BIM on the Malaysian construction industry. A qualitative approach was taken and interviews were conducted with professionals with prior knowledge in both the construction industry and BIM. Information obtained from the interviews was used to identify and categorise the determining factors. It was found that the application of BIM in Malaysian construction industry is somehow not fully effective in terms of time and cost, owing to the absence of standards in modelling and the frequent request for design changes. However, the results also show that BIM in Malaysia has the potential to be as effective as other developed countries if the major problems addressed being solved.

1. Introduction
The Architecture, Engineering and Construction (AEC) industry has been experiencing remarkable transformation, in which how building designs and information is created, portrayed and handled. Beginning with the use of two-dimensional (2D) drawings and text, it evolved into Computer-Aided Design (CAD) that enabled design process to be modelled in three-dimensional (3D) space [1]. However, CAD system only stores information such as building graphics and models that are not fully optimised for creating and handling nongraphic, as well as other information about the building. Therefore, development of an advanced processing system and software is necessary in order to utilise the benefits of information technology in the building industry. By integrating information technology into building graphics and models, Building Information Modelling (BIM) was introduced as the inevitable solution.

BIM was considered as the facility for 3D model when first introduced. The full capability of BIM, namely, digital, object-oriented and interoperable processes is far beyond what initially perceived, when used with modern communication technology. For instance, BIM has the potential to be modelled up to 6D with types of models of 2D drawings, 3D models, 4D time scheduling, 5D cost estimates and 6D facilities management [1]. The National BIM Standard-United States® (NBIMS-USTM) defined BIM as “a digital representation of physical and functional characteristics of a facility. As such, it plays the important role as a shared knowledge resource for information about a facility, which forms a reliable basis for decisions during its life cycle from inception onward” [2]. In addition, McGraw Hill Construction defined BIM as “the process of creating and using models for design, construction and/or operations of projects”.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd
Many surveys and researches show the effort of using BIM worldwide. However, the challenges still exist since industrial players have certain reasons for not adopting BIM in their projects. For developed countries, it was reported that the lack of adequate training is the greatest challenge based on research conducted in 2008. Cost of software and required hardware upgrades were reported to be the second greatest challenge. Smart-Market Reports also showed that for the years of 2009, 2012 and 2014, the lack of demand is the top reason for not adopting BIM among non-users in Australia, New Zealand and North America. An Asian country like Singapore is also experiencing similar challenges [3].

In Malaysia, the government plays an important role in ensuring BIM being successfully adopted and implemented. In 2007, BIM was introduced by the Director of Public Works Department (PWD). The potential of BIM in improving project delivery and facilities management propelled PWD to adopt BIM in Malaysia. In the same year, a BIM committee was established to identify the appropriate BIM platforms to be implemented. As suggested by the committee, the platform should be Autodesk software, such as Revit Architectural, Revit Structural, Revit MEP, Navisworks and BIM 360 [4].

Private sectors in Malaysia have been the key driver in implementing BIM since 2009. Although government initiatives are taken to adopt BIM for building industry, some contractors on the property development and Construction Company in Malaysia still find that, “BIM is mainly a private initiative driven by the larger property developers and contractors”. They also predicted this issue to go on because of the lack of government support for BIM adoption. In 2010, the construction of the National Cancer Institute (NCI) in Putrajaya became the first government project to implement BIM. The Malaysian government has also decided that BIM would be implemented in government projects by year 2016 [4]. However, evidences show that the rate of BIM adoption is still behind. A survey was conducted during a recent seminar organized by CIDB to investigate the adoption and awareness of BIM among contractors in Malaysia. Results showed that the percentage of BIM adoption was as low as 5.2%, while only 52.6% of the respondents were aware of BIM [5].

The application of BIM can be divided into three phases, i.e. pre-construction phase, construction phase and post-construction phase. BIM is applied in the pre-construction phase by providing early collaboration, which is efficient platform for sharing information and estimate accurate cost and materials take-offs based on the 3D model. For the construction phase, BIM can be used to track cash flow and work progress in real time, as well as keeping progress on schedule, reduce rework and avoid cost overrun. Post-construction benefits from BIM are better facility management, operations and maintenance works.

This paper aims at conducting an in-depth investigation to discover whether the application of BIM is really effective in Malaysia. In addition to the interview methodology used as qualitative approach, this paper critically reviews the scale of BIM’s implementation in some countries around the world. The application in the construction industry and the challenges in adopting BIM are also considered. The findings of this study would provide useful information for stakeholders in the Malaysian construction industry to identify and discover the ways of improving BIM’s effectiveness. In the long term, this study could certainly encourage its adoption and contribute to the advancement of BIM technology in Malaysia.
2. Qualitative approach for assessing effectiveness of BIM

A research on BIM can be taken either a qualitative or quantitative approach. Selecting the appropriate research strategy depends on the objectives of the study and the approaches to data collection. Qualitative approach is objective in nature and involves using variables to justify a theory or hypothesis. On the contrary, qualitative approach is more subjective in nature and emphasises on opinions, views, and experiences etc., which are often verbally expressed. A qualitative approach can be further classified under two categories, which are exploratory research and attitudinal research [6].

As mentioned in previous section, the primary aim of this research is to conduct an in-depth investigation to discover the effectiveness of BIM in the Malaysian construction industry. Due to the nature of this research, a qualitative approach was taken in order to achieve the intended aim and objectives. This approach was chosen over a quantitative approach because this research is exploratory and very subjective in nature. Many literature written and research studies conducted are focused on the adoption, implementation and challenges of BIM in Malaysia. There is limited knowledge and evidences on the effectiveness of BIM in the Malaysian context. Hence, an exploratory research was chosen, i.e. interview questionnaire forms to explore and provide a better understanding in this area of study. This approach has the potential to develop new products and shed light upon poorly understood scenarios or identify possible business opportunities.

The technique used for data collection in this research is personal interview with relevant professionals currently practicing BIM in the industry (see Table 1). Interview forms can be divided in three categories, namely structured, semi-structured and unstructured [5].

Table 1. Interviewees’ profiles

| Interviewees’ | A1  | A2  | A3        | A4        | A5       | A6       |
|---------------|-----|-----|-----------|-----------|----------|----------|
| Company       | Contractor | Project | Turn Key  | Turn Key  | C&S      | M&E      |
| background    | BIM Engineer | Management-Construction | Builder | Builder | Consultant | Consultant |
| Position      | BIM Engineer | Project Management-Construction | Manager | Senior Engineer | Executive Engineer | BIM Manager |
| Years of      | 4 | 5 | 14 | 5 | 9 | 6 |
| experience in  |   |   |   |   |   |   |
| the industry   |   |   |   |   |   |   |
| Years of      | 4 | 5 | 4 | 1 | 1 | 4 |
| experience in  |   |   |   |   |   |   |
| BIM           |   |   |   |   |   |   |
| Number of      | 8 | 5 | 2 | 2 | 1 | 12 |
| projects       |   |   |   |   |   |   |
| involved using |   |   |   |   |   |   |
| BIM           |   |   |   |   |   |   |

The most suitable form of interview for this research is semi-structured interview due to its unique characteristics [7]:

- It is carried out with individuals with known prior experience
- The interview process is based on a handout stating questions about the relevant topics in the research area
- The individual’s experiences in the relevant areas being studied is the main focus

The potential candidates to be interviewed were screened through personal contacts, friends and LinkedIn webpage, the world’s largest professional network with more than 400 million users. After that, nine candidates were selected and letters of invitation to participate in this research were sent. However, only six candidates, namely A1 to A6, replied and agreed to participate in this research (Table 1).

The duration of each interview session was approximately 45 to 60 minutes and they were conducted at various locations, where the interviewees feel most convenient. The consent form and interview
questionnaire were sent to each interviewee prior to the interview process. A total of 13 ‘open’ and ‘closed-ended’ questions were used during the each interview session with the intention to allow interviewees to share their experiences and express their opinions freely. All interviewees accepted to be audio recorded for the interview session. The interview questionnaire was developed based on three determining factors of BIM effectiveness, namely time, cost and design.

2.1. Data Confidentiality

Due to the sensitivity of some information revealed by the interviewees such as comments, criticisms and personal opinions, data confidentiality needs to be upheld within the degree of consent given by each interviewee respectively. Each interviewee was requested to select the options as follows:

- Remain anonymous and not be identified with the information provided, or
- Be identified with and given credit for the information provided.

Interviewees who chose the option to be anonymous were assigned a code, e.g. A1. Interviewees who preferred to be identified and given credit were addressed by name in this study. Since all interview sessions were audio recorded, data confidentiality was upheld by ensuring all audio recordings that were well safeguarded and not circulated. Audio recordings were necessary to ensure the accurate representation of the information, which provided by interviewees. A written consent form was presented before each interview session to be signed by both the interviewee and researcher. Thereafter, each party keeps a copy of the form.

2.2. Data Credibility

In qualitative research, the sample size is often questioned in ensuring the credibility of the data obtained. Research showed that the number of interviews for phenomenology study should be in between five and twenty-five interviews. Since BIM is considerably new to the Malaysian construction industry, there are very few companies that have implemented BIM in their projects. Also, there is only a small pool of experienced BIM users in the industry and not many would be willing to participate in this research. Hence, it is a challenge to conduct more interviews. Nevertheless, the author believes that the sample size of six interviews is adequate. Moreover, a qualitative research should focus more towards analytic generalisation instead of statistical generalisation. Besides, the interviewees represent a diverse selection of industry players. This ensures that the data collected is credible because it considers different perspectives and approaches towards BIM. Among the six interviewees, two are clients, two are contractors and two are consultants representing the Civil & Structural (C&S) and Mechanical & Electrical (M&E) disciplines.

2.3. Data Analysis and Interpretation

It is a challenge to interpret collected data in qualitative approach because they consist mainly of words. Words can carry a lot of different meanings and can be interpreted differently. Hence, the key in qualitative data analysis is “to make sense of massive amounts of data, reduce the volume of information, identify significant patterns, and construct a framework for communicating the essence of what the data reveals” [8]. The method used to analyse the qualitative data in this research is as follows:

- Transcribe all recorded interview sessions
- Identify and categorise the determining factors based on information obtained from the interviews
- Formulate general findings by identifying common patterns and comparing differences in BIM practices

2.4. Limitation

It is almost impossible to completely eliminate limitations in a research. In fact, limitations can determine the extensiveness of a research and sometimes affect the conclusion that can be drawn. There are several limitations in this research, which are time allocation, sample size and reluctance to share.

The time allocated to conduct this research was limited to seven months and works have to be completed within this period. Personal interviews require the recorded sessions to be transcribed, which
is time consuming. Also, time is needed to contact, schedule and interview candidates, which are heavily dependent upon factors such as the interviewee’s flexibility and the distance of travel.

The sample size of data collected is small because of limited number of companies and professionals who have prior experience in BIM. Also, bigger sample size would make the obtained data harder to be analysed. Since data is collected through personal interview, it would incur higher cost due to traveling to meet the interviewees. They may be reluctant to share certain information or knowledge due to various reasons, namely, job security, commercial value, and lack of incentives.

3. Results and Discussion

3.1. Time

Theoretically, BIM is said to be effective in saving time if it helps to speed up project duration, improve the response time to design changes or even save time through automated processes. Through the interviews conducted, there is no clear evidence that BIM helps to speed up project duration. Most of the interviewees as shown in Table 1 mentioned that more time is required at the design stage in order to save time at the construction phase. Some processes save time while others consume more time instead. However, the overall project duration doesn’t differ much compared to conventional methods.

In terms of project duration, A2 mentioned that “BIM can help reduce project duration only in a small margin and unless the industry is BIM-ready, the margin will be insignificant.” In fact, A2 also points out that the total project duration could possibly be longer because of two main reasons. Firstly, BIM involves working with other disciplines and secondly, some of the consultants work with only know basic modelling, hence are not able to keep up with the standards. As a result, more time is needed to recheck and ensure the model is in accordance to the standards.

On another note, four out of six interviewees have similar opinions that BIM processes involves spending more time at the design stage because of a higher level of detail and consideration compared to conventional methods. A2 revealed that working on a 3D model would prolong the documentation process because more thought is put into various parameters such as elevations, height and coordination. Conventionally, they would only draw the intention of the pipe routing and not the exact pipe routing with parameters. The drawing is a formal sketch, which will be used as tender documents, and the routing is supposed to be coordinated on site. A3 also highlighted that “this is especially true for MEP works and more time is spent on running clash detection using Navisworks.” Because of the longer time spent at the initial stage, A3, A2 and A6 had a common opinion that this would save time on site because of lesser design errors, lesser rework and faster installation process, hence reducing delays in the construction phase.

In the developed countries, it is experienced that BIM is widely used because of several benefits, which one of them is the ability to reduce project duration. A research conducted in Australia and New Zealand proved that having a project team with BIM expertise could reduce overall project duration. Another research conducted in US and UK reflected that the most significant benefit of using BIM is to reduce construction time [9]. However, the findings in Malaysia do not follow the trend as that in other countries. Interviewees found that BIM does not significantly reduce the overall project duration. One of the main reasons is because that BIM is still considerably new to the Malaysian construction industry and many construction companies are not BIM-proficient, especially C&S and M&E consultants. The lack of BIM expertise can lengthen many BIM processes such as drawings production, modelling, coordination and clash detections, hence affecting the overall project duration. In addition, the construction industry involves many parties working together and therefore much depends on each other to deliver a project on time. The saying “A chain is only as strong as its weakest link” is particularly applicable in this scenario where the inefficiency or weakness of just one party can cause the entire project to slow down even though the other parties are efficient. Hence, there is increasing importance on having project team members with BIM expertise.

Eastman et al. described the effectiveness of BIM in responding faster to design changes [10]. Even for BIM projects, the change in design process is inevitable but they can be managed more efficiently [11]. Findings support in the literature addressed, but also explained that design changes by clients can cause projects to suffer the delays, even with BIM. One of the causes of construction delay in Malaysia
is because of too many design changes ordered by clients [12]. Shourangiz et al. [11] reported that the level of frequency of design changes for BIM projects in Malaysia is very high; 67% always, 33% sometimes and 0% never. Hence, although BIM has the flexibility and the potential to respond quicker to design changes, it should not be exploited freely. The focus should not be on how to be more flexible or respond quicker, but the root of the problem may be due to indecisive clients that impose numerous design changes throughout the construction project, sometime even up to the point of construction. The later the design change is made, the higher the impact on the project duration. The MacLeamy curve, as shown in Figure 2, illustrates the preferred design process in a construction project [13].

Figure 2. Frequency of Design Changes in BIM Projects [13]

The optimum scenario will be to make as many amendments to the design and draw to a conclusive design at the end of the schematic design stage. Design development stage would involve the coordination with multiple disciplines that is time consuming and also requires the highest amount of effort. Making a design change after this stage, depending on the degree of the change means that efforts made before could become redundant and unappreciated. Therefore, coordination is crucial prior to construction process. This can greatly affect the effectiveness of BIM in reducing the overall project duration if the industry does not comprehend the consequences of last minute design changes. Companies using BIM in Malaysia have already experienced changes in terms of project timeline. Findings show that projects using BIM involves higher effort and more time in the design phase but less of both in the construction phase. The findings were in accordance to the MacLeamy Curve, as shown in Figure 4. This outcome is similar to what being practiced in other countries. This would naturally happen because BIM processes increase the level of effort and prolong the design phase. As a result of better planning and coordination, delays caused by clashes, change orders (COs) and requests for information (RFIs) can be eliminated as much as possible during the construction phase to help the project stay on schedule.

From these observations, it is clear that BIM has not been effective in reducing overall project duration in Malaysia. The current situation indicates that BIM has the potential to conserve time in some ways but at the same time being hampered by delays in other related aspects. BIM helps save time through automated calculations, drawings production, reduced design errors, lesser rework and faster installation process on site. On the other hand, BIM consumes more time on documentation, modelling, coordination and in the event of a late design change.

3.2. Cost

Cost seems to be one of the main barriers for BIM implementation in Malaysia. CREAM documented that it is a challenge for SME’s in Malaysia to implement BIM because of high investment in hardware, software, staff training, employing staffs with BIM expertise, obtaining certifications and licenses as well as extra overhead cost. In fact, having BIM capabilities does not guarantee that SME’s will get
projects. Since the initial capital spent on implementing BIM is high, companies are uncertain on the possibility of recovering ROI [4]. These findings agree to that mentioned in the literature so it can be deduced that the same challenges can be generalised for most companies in Malaysia.

Despite the high cost, some companies are willing to take the risk because of the potential benefits they believe to gain out of BIM. Based on a research conducted in North America, key findings reveal that two-thirds of BIM users are experiencing positive ROI and 93% of BIM users believe there is potential to gain more value in the future [14]. However, this is not reflected in the findings of this study. Most of the interviewees can only say that it is a long-term investment. This can imply that they are not generating positive ROI. It can be assumed that leading companies in Malaysia using BIM generally suffer losses or only break-even at initial years but they gain experience and learn lessons along the way. Their perspective is that, investing into BIM now will reap greater benefits in the future. None of the interviewees could provide figures of their company’s ROI and this is possibly because of two reasons. Firstly, companies may not have an acceptable method of calculating ROI in BIM and secondly, the information is confidential and could not be revealed at this point of time.

Findings in previous section of this report also show that the industry is generally not BIM-prepared and the Malaysian construction industry is lacking expert users in BIM. As a result, this could be one of the possible reasons why Malaysia is not experiencing positive ROI. McGraw Hill Construction [14] reported that only 38% of beginners see positive ROI with BIM compared to 87% of expert users, as tabulated in Figure 3. Hence, as more users gain experience and proficiency, it can be predicted that their ROI will improve over time.

Besides that, findings also show that BIM is seen as a way to stay ahead in the game and gain projects. Research reveals that some of the top business benefits of BIM are marketing new business to new clients, proposing new services with BIM and retaining repeat business with past clients [14]. As more clients discover the benefits of BIM, there will be more requests for BIM to be implemented in their future projects. Companies with BIM expertise will have an advantage and a head start in the industry. As can be seen, BIM in Malaysia has not been effective in generating ROI to recover the high implementation cost in comparison to other developed countries such as North America. Broadly speaking, BIM is currently not cost-effective in Malaysia. Since BIM is slowly gaining popularity in Malaysia, the scenario is expected to change and improve drastically in the coming decade. Because of the high initial capital needed to implement BIM, not many companies are willing to venture into BIM at this point of time.
3.3. Design

Industry players in Malaysia have benefited from some of the design benefits offered in BIM. Findings show that the ability to visualise building models in 3D helps to improve the quality of building designs. Adam Meeker, Senior Architect / Associate at FTC&H testified that the use of 3D models helps with faster and earlier decision making, improves collaboration and coordination between disciplines, and lesser clashes among systems. In the former days, the skill of visualising drawings in 2D and interpreting them comes with many years of working experience in the industry. Visualisation in 3D has assisted the younger generation of professionals, especially fresh graduates with little or even no experience in the industry to catch up and better understand the design model they are working on. McGraw Hill Construction offers supporting evidence, where clients in the UK and US acknowledges visualisation in BIM as a potent benefit because it provides a better understanding of the proposed design.

Autodesk, Inc. recorded customer success stories about how BIM tools have been utilised to help coordinate, identify and resolve design clashes before starting the construction. BIM tools have provided the suitable platform for the transition from conventional methods of overlaying 2D CAD to incorporating building models across disciplines into a single building model for coordination purposes. This process could be carried out in advance, during the design development phase. Although there have not been any recorded success stories published from Malaysia, findings proved that companies engaging BIM have been gaining design benefits in some ways. For Malaysian scenario, coordination of building designs between disciplines should be taken a step forward in future.

In addition, findings also show that there are struggles in sharing building models and integrating models from different disciplines on a single building model over a cloud server. A study showed that the reluctance of architects to share their model is because of liability reasons. As a result, contractors have opted to creating their own model for construction purposes. This is because architects and contractors may have completely different ways or standards of modelling. The current scenario in Malaysia is very much similar to the literature mentioned, in which sharing of models do not take place, every party creates their own model individually to suit their respective needs and coordination is only done over technical meetings between parties involved. The effectiveness of this working practice remains arguable because duplication of efforts exists among project teams. Cloud services hosted by Autodesk provide a platform for collaboration in the cloud and 3D models can be updated in real time by project teams. Nevertheless, the effectiveness of BIM cloud services in Malaysia is also very vague because of the working practices and lack of modelling standards.

Therefore, the key findings reveal that BIM tools generally have been effective in Malaysia. A step forward from 2D CAD to 3D modelling helped improve visualisation and coordination as well as detect clashes and design errors. Despite several challenges in design practices, BIM processes are able to make a positive impact to the industry. As more and more industry players catch up with BIM, the effectiveness of BIM in this area is expected to remarkably improve. There are still a lot of design benefits to explore in the days to come.

4. Conclusion

This study successfully investigated the effectiveness of BIM in the Malaysian construction industry by conducting a qualitative approach and through interviewing professionals. The objectives laid out in the introduction section were also well achieved. Based on the findings, BIM is effective in design but not the same in the areas of time and cost. Therefore, it could be concluded that BIM application has generally not been effective in Malaysia. However, it is proven to have good effectiveness in other countries which have implemented BIM for a longer period of time. It could be deduced that in a long term, the effectiveness of BIM in Malaysia has the potential to be on par with those countries. So, the problems addressed in the current implementation of BIM need to be solved through the cooperation of government bodies and industry players. The government can also explore or consider the option of making BIM mandatory for building projects, since this would greatly improve the adoption of BIM and its effectiveness. Trial and error, exposure and experience with BIM will equip professionals with the skills to excel in BIM.
5. References

[1] Storer D 2012 Six Dimensional Building Information Modelling Retrieved on March 8th, 2016 from http://www.hjhigh.com/news-and-media/market-trends/six-dimensional-building-information-modeling/

[2] National Institute of Building Sciences 2015 National BIM Standard-United States® Retrieved on March 4th, 2016 from https://www.nationalbimstandard.org/files/NBIMS-US_FactSheet_2015.pdf

[3] Zahrizan Z, Ali N, Haron A, Marshall P A and Hamid Z 2013 Exploring the adoption of building information modelling (BIM) in The Malaysian construction industry: A Qualitative approach. International Journal of Research in Engineering and Technology 02(08) 384-395

[4] Construction Research Institute of Malaysia (CREAM) 2014 Issues and Challenges in Implementing Building Information Modeling (BIM) for SME’s in the Construction Industry. Retrieved on April 2nd, 2016 from https://www.cidb.gov.my/cidbv4/images/pdf/announcement/BIM/bim%20seminar%20%20workshop%20for%20malaysia%20construction%20industry.pdf

[5] Construction Industry Development Board (CIDB) 2014 Contractor's Acceptance of Building Information Modeling (BIM) Towards Improvement of Project Performance and Profitability Retrieved on April 2nd, 2016 from https://www.cidb.gov.my/cidbv4/images/pdf/final%20bim%20for%20contractors2.pdf

[6] Naoum S 2013 Dissertation research & writing for construction students, 3rd ed. (New York: Routledge) pp 10-15

[7] Merton R and Kendall P 1946 The Focused Interview American Journal of Sociology 51(6) 541-557

[8] Patton M 1990 Qualitative evaluation and research methods (Beverly Hills, CA: Sage) pp 169-186

[9] Yan H and Damian P 2008 Benefits and Barriers of Building Information Modelling Proc. of 12th International Conference on Computing in Civil and Building Engineering (Beijing: International Conference on Information Technology in Construction (INCITE 2008)) pp1-4

[10] Eastman C, Teicholz P, Sacks R and Liston K 2011. BIM Handbook 2nd ed (Hoboken, New Jersey: John Wiley & Sons, Inc.) pp 10-25

[11] Shourangiz E, Mohamad M, Hassanabadi M, Banihashemi S, Bakhtiari M and Torabi M 2011 Flexibility of BIM towards Design Change Proc. of 2nd International Conference on Construction and Project Management (Singapore: IACSIT Press) pp 79-83

[12] Hamzah N, Khoiry M, Arshad I, Badaruzzaman W and Tawil N 2012 Identification of the Causes of Construction Delay in Malaysia International Journal of Civil and Environmental Engineering 6(12) 1063-1068

[13] The Division 4 Triclinium 2016 Of the MacLeamy Curve, Efficient Design, and Expensive Money-Or Why Developers are a Breed Apart! Retrieved on March 8th, 2016 from http://division4triclinium.blogspot.com/2013/06/of-macleamy-curve-efficient-design-and.html

[14] McGraw Hill Construction 2009 The Business Value of BIM Retrieved on March 8th, 2016 from https://www.trane.com/content/dam/Trane/Commercial/global/markets/Architect/building-information-modeling/SMR%20BIM%20%20FINAL%20rev.pdf