Towards 3D As-Built – What Say The Professionals?

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Key words: 3D interior modeling, 3D as-built, Building Information Modelling, laser scanning

SUMMARY

Building Information Modelling (BIM) is getting more attention from the professionals due to the benefits it brings in Architectural, Engineering, Construction and Facility Management (AEC/FM) areas. Elements in BIM, especially the 3D modelling, play an important role. Although BIM covers the overall process of building construction, the component of 3D modelling in BIM during post construction, which can also be known as 3D as-built, is underutilized due to several issues, specifically when used in existing buildings. This paper will highlight the current concerns in generating 3D interior models, which in some applications can be used as the 3D as-built, based on the feedback obtained from industry professionals. These concerns were obtained from surveys made towards surveyors, engineers, architects and facility / project managers. The importance of the survey is to highlight the disadvantages of current methods in producing 3D interior models. Moreover, the results can also reflect the readiness of the related professionals in extending BIM, in particular 3D modelling, for post construction purposes. All survey respondents have agreed that the existing, traditional laborious methods have disadvantages in visualization, functionality and standardization, apart from poor accessibility and poor data capture. However, to use laser scanners to generate 3D models has its own limitations, mainly due to cost, and restrictions in software and functionality. From their opinions, there is a need to develop such required solution to overcome these disadvantages and limitations to ensure that BIM can be expanded to post constructions. In conclusion, 3D as-built can be generated especially for newly constructed buildings that implement BIM at the starting of preconstruction by optimizing the same 3D model used during construction. However, for extending BIM to existing buildings, there are limitations that can put off professionals, especially in generating the 3D as-built. It is important for BIM to be fully utilized and expanded to post construction, especially since BIM in pre and during construction has been fully exploited and matured. Therefore, more research is needed to overcome these limitations as now is the perfect time to focus on BIM for post construction.

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1. INTRODUCTION

3D modelling of building interior has gained a lot of interest from AEC / FM (Architectural, Engineering, Construction and Facility Management) professionals due to the increasing development of Building Information Modelling (BIM), along with the rapid development of 3D laser scanners. The building layout developed and used in BIM can be applied throughout the life cycle of a building, starting from pre-construction to post-construction, for the purposes as shown in Figure 1.

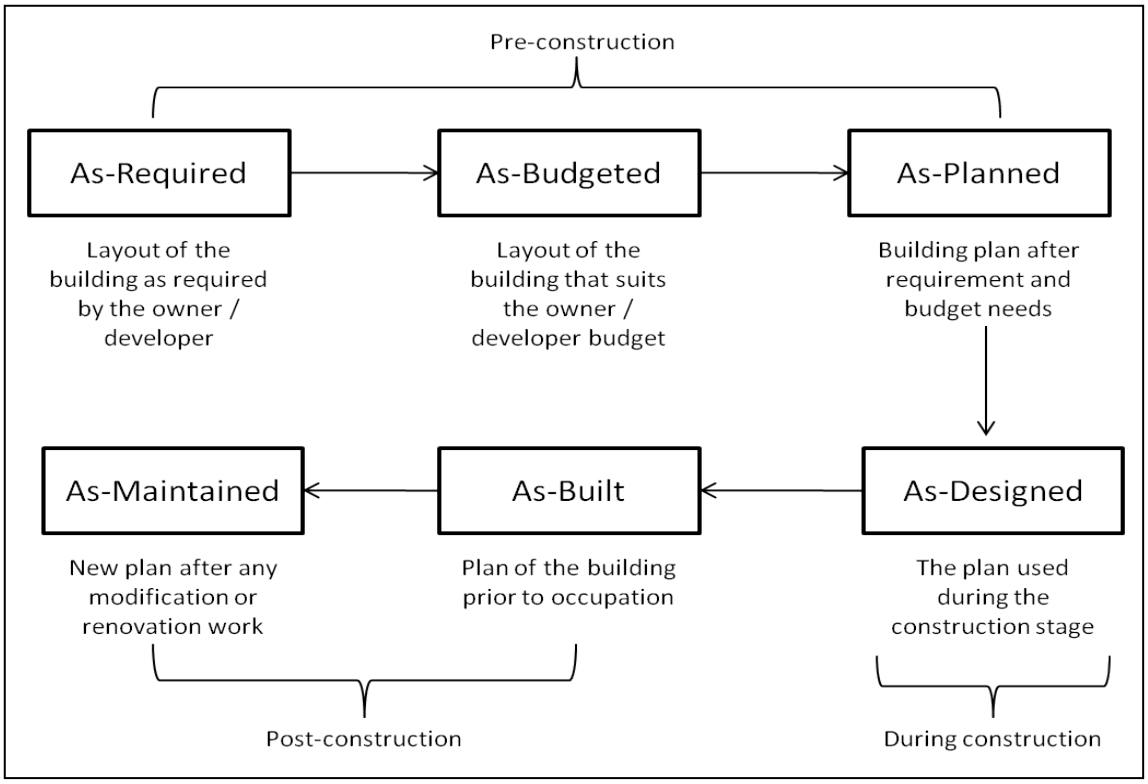

Figure 1: Building layout continuity. Notice that one single drawing can be used throughout the building lifecycle

By using the same building layout from pre-construction to post-construction, professionals as well as users of the building can use it as 3D as-built, where it can be used for planning, as well as assisting modification or renovation work in the future. But, since BIM only began in the late 1990s, so most existing buildings do not have BIM, professionals who

want to create 3D as-built need assistance using relevant sensor hardware like 3D laser scanners as well as specific software to process the data.

However, the usage of BIM is maturing in constructing new building, but not in the post-construction process, especially towards existing, in-used buildings. Thus, a study is needed to find out what is really happening – why is it slow? Is it hard to develop such a 3D layout for existing buildings? What about the awareness – are all professionals knowledgeable about the use of this technology? What about the perceptions of experts who have been using laser scanners and associated software to create this 3D as-built?

The most suitable approach to gather all the above information is by using a survey. A survey is a method that has been proven in originality, discovery and validity of data, where usually factors such as time, effort and money need conciliation (Gillham, 2008). This survey should be concentrating on interviewing professionals (both experts and potential experts) and those who have been involved in using laser scanners to develop interior modelling (i.e. 3D as-built) directly or indirectly as they are the current and potential users whom may use the outcome of this research in the future. In this survey, individuals were selected among two categories of professionals (people who work in AEC / FM areas) namely: those who are familiar and have used the method as well as professionals that aware of the method but haven't used it yet (referred to as the experts); and people who are not aware of the method (both referred to as potential experts). The findings can be used to motivate, justify, inform and support the related research in the future.

This paper will concentrate on the survey method – from designing the questionnaires to the selection of professionals and processing the outcome to find out what are the current scenarios in generating 3D as-built. The whole survey was conducted using interviews and indirect communication through telephone and email contact. Results obtained from this survey will be used as guidance in distinguish the trend in the development of 3D as-built for existing buildings among the professionals.

2. SURVEY PREPARATION

2.1 Research Questions

The questionnaire developed must be designed to answer the research questions:

1) How much awareness do related professionals have of 3D as-built design and development?
2) What are the limitations of current approach in developing 3D as-built that can be overcome?

2.2 Drafting and Designing the Questionnaire

In order to find out what is the present situation in developing the 3D as-built using 3D laser scanners, the proposed questionnaire needs to include the following:

1) Background of respondents. From here, classifications of group or type of respondent according to their professional area can be done, which may influence the outcome.

2) The awareness of respondents. As one of the research questions is about the awareness related professionals have in 3D as-built design and development, this can be used to observe on respondents' knowledge and understanding of 3D laser scanners and related applications. To know the level of awareness is important as this technology is quite recent and many may be unfamiliar with it.
3) Recent methods in developing 3D as-built. This element can be used to answer the research question. Results obtained can be used to determine current approach limitations and disadvantages from both a hardware and software point of view.

After suitable topics and questions have been shortlisted, the draft of the questionnaire was distributed to two people (one specialist who is involved in a related area of application, while another one is a non-specialist), to pilot the questions. By distributing it to both a specialist and non-specialist, the questionnaire can be improved to ensure it covers all the important aspects that are needed. In addition to that, responses from this pilot study can be used as a guidance to redesign the questions to make sure the respondents understand the questionnaire whilst being informed from the viewpoint of potential responders. After all the feedback from this pilot study has been considered, necessary amendments have been made to the questionnaire before it can be distributed to the potential respondents. This pilot step of study is conducted as according to Gillham (2008).

2.3 Finding the Respondents

From the literature, there are several area that are currently being associated with 3D as-built using laser scanners, which includes AEC/FM and historical building preservation (Tang, *et al*., 2010) (Vosselman & Maas, 2010). Therefore, the targeted respondents for this survey would be people from these industries.

Laser scanning operations can be divided into two, according to its application – terrestrial and airborne. According to Vosselman and Maas (2010), terrestrial laser scanning can be divided into several applications – building extraction, forestry, engineering, cultural heritage and mobile mapping. Hence, the selection of respondents would be the people who are currently working in this area, especially related to interior modelling (i.e. 3D as-built). Table 1 summarizes all the potential professionals:

Table 1: Summary of potential respondents for this survey

Applications	Areas	Related professionals
Engineering (building extraction, reconstruction of industrial sites, structural monitoring and change detection, corridor mapping)	AEC / FM / Forensic	− Surveyors − Civil engineers − Mechanical & Electrical (M&E) engineers − Architects − Facility / project managers − Geospatial intelligence
Cultural heritage	AEC / FM	
Mobile mapping (indoor and outdoor)	AEC	

Indoor mobile mapping applications like Simultaneous Localization and Mapping (SLAM) are mostly being done by researchers, while laser scanner providers often offer outdoor mobile mapping solutions and services, such as road and railroad-track based systems. Since they do not belong to the professionals as defined and referred to in this study, the application of mobile mapping will not be included in the survey. All these professionals were identified and contacted based on information obtained from the internet as well as contacts (meetings during conferences, personal contacts, recommendations by others).

3. THE RESPONDENTS

After potential respondents have been recognized, several contacts have been made among the related companies and firms to be involved in the survey. All the shortlisted contacts are from organizations based in United Kingdom (UK) and Malaysia (M). 18 companies have been contacted:

- Surveyors companies: 6 (3 UK and 3 M)
- AEC / Architect firms: 5 (3 UK and 2 M)
- Estates / Facility Management companies: 3 (2 UK and 1 M)
- Historic Environment Advisers: 2 (Both UK)
- Professional institutions / associations: 2 (Both UK)

From the above, 3 organizations (one association, one historic environment adviser and one surveyor company) did not contact back while one professional institution refused to participate, making the response rate 78%. From these 14 companies responded, 19 individual respondents were involved in the survey. Their backgrounds are as listed in Table 2. As these respondents covered all the respective professionals in the relevant applications and areas (as suggested by Vosselman and Maas, 2010 – refer to Table 1), the number of respondents is appropriate enough to generate valid and convincing results that can be used to answer the research questions posed. Summary of the respondents' background can be found in Figures 1 and 2.

Table 2: Details of respondents

Companies / Firms	Positions	Gender
5 Surveyor companies:		
1) Surveyor A (UK)	1 surveyor	Male
2) Surveyor B (UK)	1 surveyor	Male
3) Surveyor C (M)	1 surveyor	Male
4) Surveyor D (M)	1 surveyor	Male
5) Surveyor E (M)	1 surveyor	Male
5 AEC / Architect firms:		
1) AEC / Architect firm A (UK)	2 architects	Both male
2) AEC / Architect firm B (UK)	1 architect	Female
3) AEC / Architect firm D (UK)	1 architect	Female
4) AEC / Architect firm C (M)	1 M&E engineer	Male
5) AEC / Architect firm E (M)	1 civil engineer	Male
3 Estates / Facility Management companies:		
1) Estates / FM company A (UK)	2 managers, 1 architect	1 male and 1 female manager, 1 male architect
2) Estates / FM company B (UK)	2 managers	1 male and 1 female
3) Estates / FM company C (M)	1 civil engineer	Male
1 Historic Environment Adviser company (UK)	1 geospatial intelligence, 1 project manager	Both male

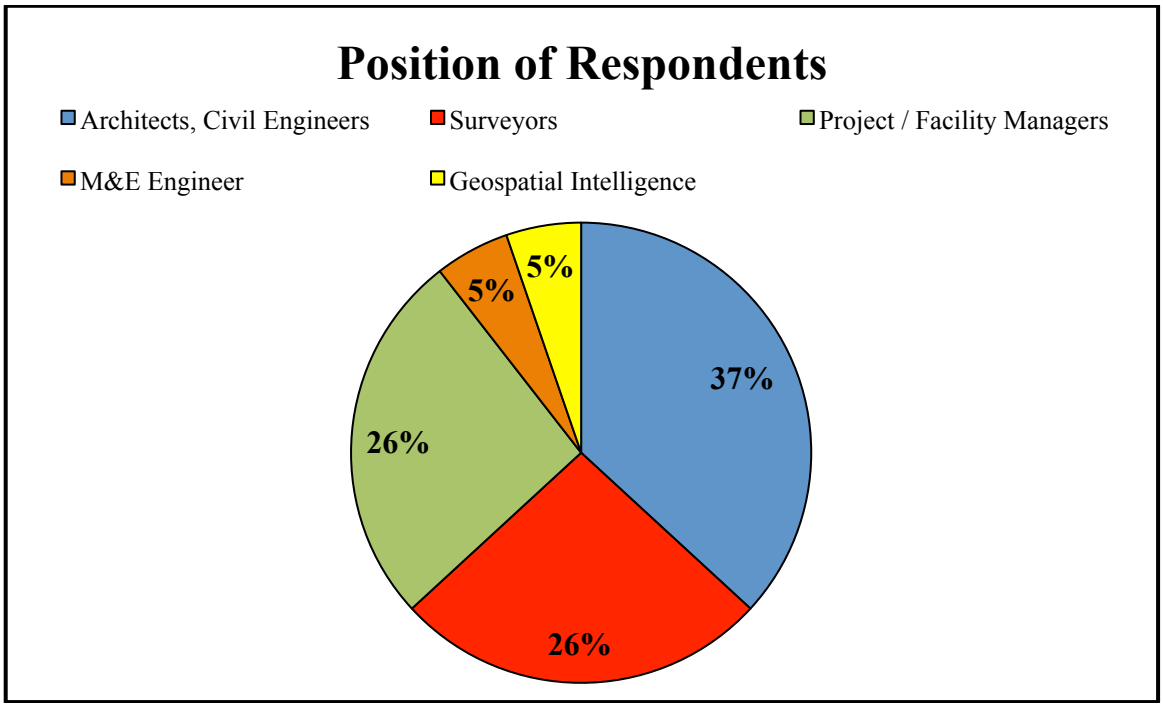

Figure 1: Respondents background by position

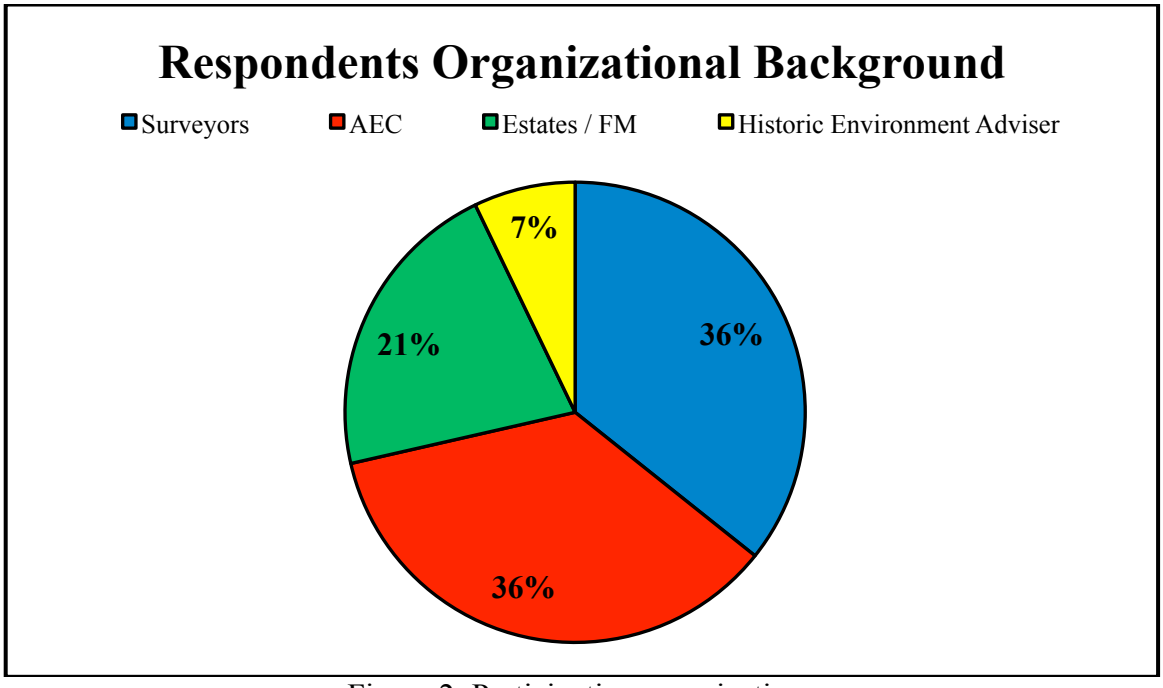

Figure 2: Participating organizations

4. RESULTS AND DISCUSSIONS

Before the survey was conducted, respondents were asked whether they are familiar with the development of 3D as-built using 3D laser scanner. Hence they were labelled as "experts" to indicate that they are aware of the approach otherwise they were "potential experts". Due to limited literature in this area and as the technology is still emerging, some respondents, like architects and engineers from smaller construction firms, are still not aware about the usage 3D laser scanners and the capability of collecting 3D data that can generate a 3D as-built. In this survey, potential experts consisted of 47% of total respondents whereas the remaining 53% are experts (respondents who are familiar and / or have used the method).

The respondents were then initially asked to answer the survey, but as the interview become more involved, open-ended questions were also being asked on related matters such as comments on the existing, traditional methods of producing as-built in order to figure out their disadvantages. The existing traditional method here refers to the manual measuring work (using measurement devices like tape measures or laser range finders) and transferring those readings into drawings using CAD software to create the as-built. Questions on the development of 3D as-built from laser scanner data were also being asked to investigate its limitations. The findings about both existing traditional methods as well as the 3D as-built using laser scanner approach are summarized in Figures 3 and 4 respectively.

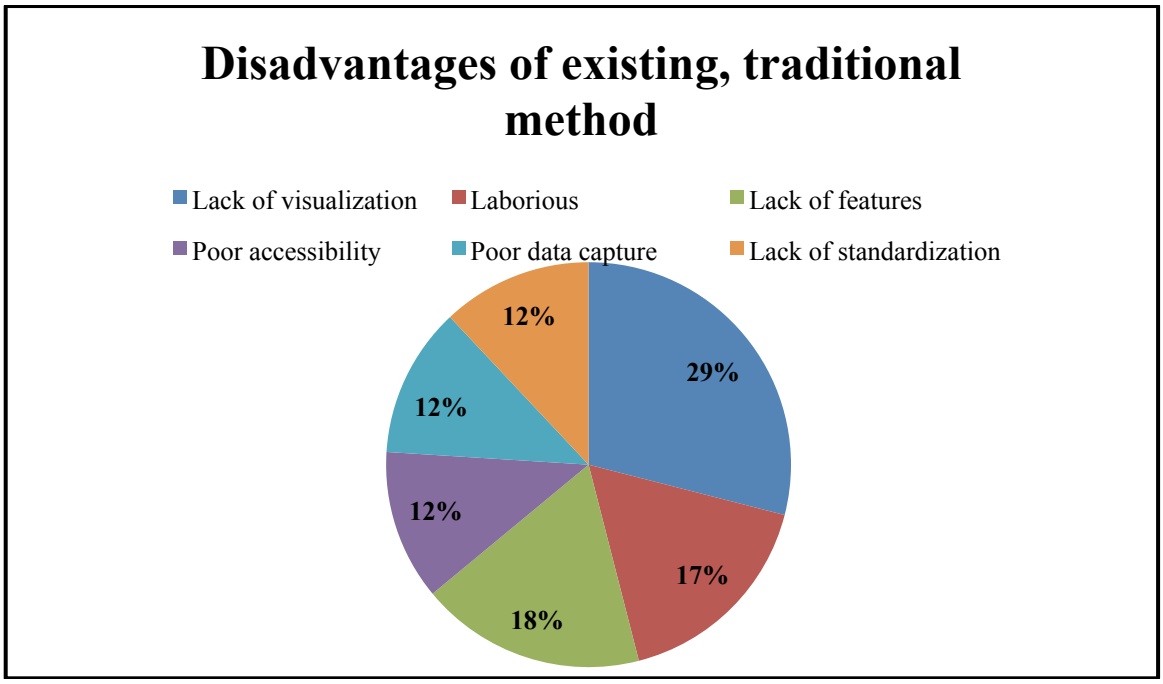

Figure 3: Disadvantages of existing traditional method in producing as-built according to the respondents

In discussing the disadvantages of existing traditional methods, respondents who have direct communication with non-experts (non-professional people or public who use the experts' skills) agree that the lack of visualization of the existing method is the major disadvantage. Most of them are the project / facility managers who deal with non-experts as

well as surveyors who need to supply data to non-experts. These limitations are also being highlighted by professionals currently working in BIM in their books (Kymmell, 2008) (Smith & Tardif, 2009).

Meanwhile, experts who have to go to the site and collect the interior data (architects and surveyors) agree that the laboriousness of the task and data capture factors are the disadvantages of the existing method, as it is tedious, time consuming and requires a lot of manual effort. Professionals who work with facility management and maintenance organisations agree that the current methods have accessibility issues, especially when they have to deal with different software packages to access the same information, since CAD-based software records the drawings for the interior but facility management-based software has the information about space and facilities within them. Features and standardization issues are among the factors that need to be overcome or are dealt with by professionals, who use the existing method as a standard for FM-based software where information is tabular and lacks detail. There is no specific standard between different software packages, so when professionals refer to a particular room or location, the lack of a standard referencing system leads to misunderstanding and confusion. These limitations were also being mentioned in FM books (Sule, 2009) (Park, 1998) (Booty, 2009).

The next part of the survey asks about the current limitations in using laser scanner data for building interior modelling, and is specifically being aimed at professionals who are familiar and have used the method i.e. the experts. As a result, 80% of experts agree that cost is the most important factor that affects the usage of this method. Meanwhile, 70% of the experts voted that the current software capable of processing 3D point cloud data (from 3D laser scanners), has some limitations including the need for manual processing, lack of ability to handle occlusions and clutter problems, large data handling issues, and also its insufficiency in data accessibility, as one needs to have access to the same software to open the model. Experts who have dealt with various laser scanner manufacturers and surveyors have chosen collaborative issues as one of the limitations, as different hardware comes with its own data format and processing software, and so far there is no standard platform developed to handle this within the industry. One surveyor who has used this method has also mentioned about security issues, as he has problems with sharing the data with his clients, and currently using the web is not secure enough to ensure the confidentiality of the data. Apart from that, the enormous size of point cloud data produced by the state-of-the-art laser scanners makes it difficult to produce a dataset available for general use or research purposes.

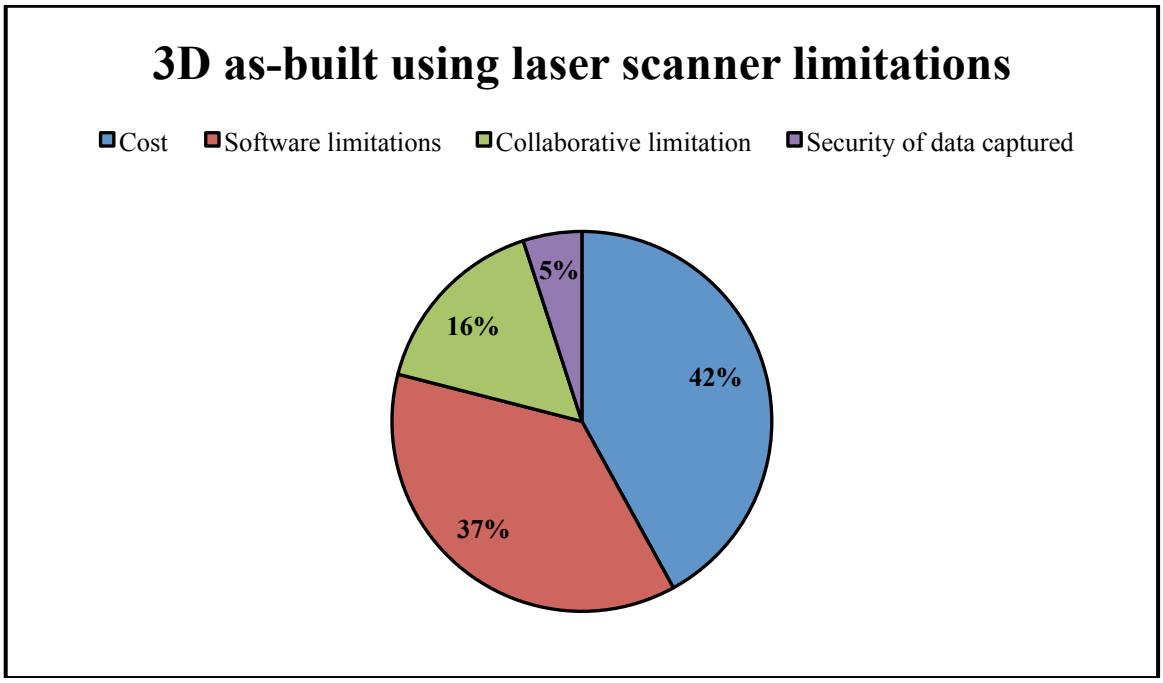

Figure 4: Current limitations of 3D as-built development using laser scanner

Based on the results of this survey, there is a need to develop a solution to handle these limitations especially on the development of 3D as-built from laser scanner data. As a summary, Table 3 highlights the features offered by commercial software, as shown in the "offered" column, compared with the needs of professionals as uncovered by this survey (as in the "required" column). Therefore, research should be concentrating on how to handle the limitations currently "offered" by the software by developing solutions "required" by the professionals, in order to fully utilized BIM towards post construction for existing buildings.

Table 3: Offered vs. required - summary of current softwares' limitations and the needed features based on the feedback

Offered	Required
− High in cost	− Low-cost
− Manual process	− Automatic
− Individual file format	− Laser scanner file format (ASCII)
− High density with complete data required	− Can handle missing data
− Library dependant	− No library needed
− High processing time	− Real-time
− Requires CAD knowledge	− No CAD background needed
− No semantic information	− Semantic features included

5. CONCLUSION

This paper contributes towards a review on current usage of laser scanners to develop 3D as-built using a survey of 19 industry professionals. Although the number of respondents is small, it is sufficient as it covers all related areas as suggested from the literature. These

professionals are identified individuals who have been using or could in the future use 3D as-built BIM, such as architects, surveyors, AEC engineers, facility managers and geospatial intelligence. Based from the results, they agreed upon disadvantages of the existing, traditional approach in developing as-built, and using laser scanners to build up 3D as-built is much appreciated. However, the majority of experts agreed that the current process of 3D as-built has limitations. As a conclusion, although the usage of BIM in AEC / FM is promising, to fully extend it further towards post-construction especially to existing buildings is still a long journey with many software and hardware issues needed to be addresses by developers.

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BIOGRAPHICAL NOTES

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