Development of Building Information Modelling (BIM) Model to Enhance Services in Maintenance of Public Building

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Abstract

Maintenance of a building has a purpose to preserve the building in accordance with the initial conditions on functional, structural, and aesthetic. In addition, maintenance aspects cover a long life cycle in a building, thusq maintenance costs tend to be larger than other construction phases. DPR RI building is one of the government buildings owned by the state which also can not be separated from maintenance and financing aspect. Building Information Modeling (BIM) is a system and tools approach used in the aspects of building maintenance. The purpose of this research is to identify factors that influence the development of BIM-models and how to develop BIM-models to improve services in building maintenance. The research was conducted by validating the content to the experts of building maintenance and BIM to find out the influencing factors and further develop the BIM-model by taking of historical data and field survey. From the data then conducted an qualitative analysis based on the influencing factors. From this research, it is found that influential factor in BIM-model development that improve service in maintenance of Government building and found steps that can be done to enhance service in maintenance at Government building by using Building Information Modeling.

Keywords
Building Information Modelling, building maintenance, services, public building

1. Introduction

Maintenance may also be defined as "the necessary services and activities provided to conserve, protect and maintain the structure and form of the building upon completion or after any repair or replacement of the current standard in order to function at its entire age without interfering with its features and use original" (A.L. Olanrewaju dan A.R. Abdul Aziz, *Building Maintenance Process*, 2015).

In addition, the constraints have also been mentioned by Ibrahim Motawa and A. Almarshad (2013), that adequate information is needed regarding the products available for maintenance operations, such as specifications, previous maintenance work, professional list of specialists to do the work, etc. It will support the preventive maintenance activities.

With the development of information systems so rapidly today it certainly has an impact on the construction that can be seen as a solution to the classic problems that often occur. The current growing industrial revolution sees that the proposition obtained by BIM data during the project life cycle can improve the efficiency of facilities management functions. BIM is defined as the process of generating, storing, managing, exchanging and sharing building information in a reusable and usable manner (Vanlande et al., 2008).

According to the Bureau of State Property Management (2017), to support information systems on maintenance of Government buildings, that currently under development, it is hoped that BIM can assist and integrate information into the system in order to simplify and streamline maintenance activities and Government building maintenance. Therefore, this research is expected to contribute BIM's development in improving services in maintenance conducted at Government buildings.

2. Literature Revies

2.1 Building Maintenance

Building maintenance activities consist of several series of work processes involving planning, control, and decision making. Maintenance of a building can also be defined as "work" in order to maintain, store or enhance parts of buildings to improve the performance of buildings and services and surrounding areas, to accept standards and to maintain utility and building value (B. Pļaviņa & I. Geipele, 2013).

According to the British Standard (BS.3811), maintenance is a combination of activities, both from the initial appearance of ideas, activities related to finance, organization or physical activity of maintenance itself which is done to maintain something in conditions that should be in accordance with the requirements. The Directorate General of Cipta Karya of Public Works Ministry has also issued a definition of maintenance in accordance with the decision of The Directorate General of Cipta Karya No. 295 / KPTS / CK / 1997 ie Maintenance is an attempt to maintain the condition of the building to keep functioning properly or in an effort to improve the shape and guard against the damaging effects. So in short, the definition of maintenance can be either corrective or preserve and, more importantly, has a value, although sometimes maintenance is not valued.

The process of organizing and tracking facilities is also quite a tough job with many types of facilities. In general, facility managers and staff in carrying out maintenance tasks require access and inspection at desired locations (Yu Chih Su, et al., 2011). In addition, most maintenance processes currently require paper containing the information needed for inpection, such as 2D drawing. Conventional maintenance procedures like this will certainly require a procedure and a long time, also it become less efficient.

Research in the UK mentions the selection of appropriate maintenance strategies for each equipment or system is a very complex task because of the difficulty of data collection, diversity of components and functions, and a large number of criteria to be taken into account and subjectivity. The decision maker (ie system owner or service agent) must decide the most appropriate maintenance strategy for the equipment among a set of possible alternatives, such as risk-based maintenance, condition-based maintenance, time-based maintenance, etc. Facility management can be considered in three dimensions: technical, economic and social factors (Gajzler 2009; Thiel 2008).

In the research of M. Shafiee (2014), the selection of appropriate maintenance strategies can be by applying Multiple-Criteria Decision Making (MCDM) approach. There are several criteria to consider in selecting appropriate and quantifiable maintenance strategies (such as hardware / software costs, training costs, availability of equipment) and qualitative (difficult to measure) such as safety, flexibility, product quality. In the above criteria can be categorized into 4 categories, namely economic, technical, social, and environment.

2.2 Building Information Modelling (BIM)

BIM has several definitions that are described from various perspectives and lifecycle perspectives. However Azhar (2012) explains that in general the purpose of BIM is to transfer data into FM operations. So BIM provides an integrated model with the database to store all the information. Therefore, BIM in FM can be defined as a real-time

documentation tool in the repository / storage place to organize information about the building over the life cycle, so the Owner can use it to manage the facility.

Some literatures and researches indicate some advantages or benefits, both internal and external projects / organizations, acquired in adopting BIM, especially for facility management. Nor Diana Aziz et al. (2016) cites several benefits that can be gained by facility managers, ie. operational costs that become more effective, shorter decision-making times, BIM can be a source of information in decision making, better documentation systems, more work and collaboration flexible, up-to-date information, and can detect disputes.

Brewer et al. (2012) states that the challenges of using BIM on construction projects can be grouped into: 1) technical challenges, which are generally conflicts and issues concerning data sharing between teams and BIM software problems; 2) skills and training challenges, which are particularly relevant to project team project members and improve their skills; 3) legal and procedural challenges referring to the absence of standard and legal definitions for BIM's professional responsibilities; and 4) cost challenges, which sometimes hinder construction companies from transforming and upgrading their current systems into a BIM-oriented system.

In general, challenges/obstacles need to be identified and addressed before implementing BIM on the project to obtain the desired results. The previously mentioned challenges may turn out to be the key to success if they have a strategy to overcome those challenges.

But in Indonesia itself does not seem to use BIM for maintenance, especially in Government buildings. Generally, the use of BIM is currently widely used in Indonesia, namely in the design and construction phase undertaken by consultants and contractors (source: Chris Santoyo, Revit Implementor, 2017).

3. Methodology

Table 1. Research Methodology

RESEARCH QUESTION	RQ 1	RQ 2
	What are the factors affecting the development of BIM to improve services in maintenance of Government buildings?	How to develop BIM to improve services in maintenance of Government buildings?
Variable X	*Building Information Modelling (BIM)*	
Variable Y	Services in Maintenance of Government Buildings	
Research Strategy	Survey	Case Study
Input	Books, Journals	Historical and existing data related to building maintenance of Government buildings
Instrument	Expert Validation Questionnaire	Case Study Questionnaire
Data Analysis	Expert Survey (Delphi Method), Miles and Huberman (Qualitative Analysis)	Qualitative Analysis
Output	Factors that influence the development of BIM-models to improve service on maintenance of Government buildings	Development of BIM-model to improve service on maintenance of Government buildings

In this study there are several stages to achieve the research objectives. Based on Table 1, the researcher first determines the factors that influence the development of BIM to improve services in maintenance of Government buildings (RQ-1). The output of RQ-1 is obtained by determining the independent variable and dependent of the research and then content validation survey to the building maintenance expert as well as BIM experts.

Furthermore, to obtain the output of RQ-2, the researcher conducted a case study of Building Information Modeling (BIM) on one of the existing building of the Government especially in the maintenance phase. Based on inputs obtained in RQ-2, qualitative analysis was conducted in order to develop BIM-models that can be used to improve service on maintenance of Government buildings. In addition to the existing condition of existing buildings there is no

BIM modeling, then in this study also conducted the existing building modeling on BIM through Revit Architecture. And final analysis result in this research also by final validation to expert of BIM.

4. Results and Discussion

According to Miles and Huberman (1984), there is a means of data analysis that qualitative done interactively and lasted continuously until complete, so the data is saturated. Activities in analyzing this data consists of several stages, namely data reduction, data display and conclusion drawing/verifications.

In the maintenance itself can be categorized into 4 aspects, namely the economic aspects, technical aspects, social aspects and environmental aspects (Shafiee, 2015). Each aspect has sub-indicators/factors that support each aspect. Based on the results of content validation conducted to the experts obtained that the 4 (four) aspects are an important and influential aspects in the maintenance of government buildings. From all 4 (four) aspects of maintenance, consist of 24 sub-indicators, while the sub-indicators of BIM consists of 16 sub-indicators as a whole.

The first objective of this research is to know what factors are influential in developing BIM-model to improve service on maintenance of Government buildings. After obtaining the factors of building maintenance and BIM from literature reviews, then the next step at the data reduction stage is validate the factors to the experts to know whether the factors are important and affect the improvement of building maintenance services in government buildings. At the data reduction stage it is found that Y1.6 Return on Investment (ROI) is considered unimportant factor according to the experts of building maintenance. As for the 16 sub-indicators of BIM are considered important by the expert BIM as shown in Table 2 below.

Table 2. Factors that Affect The Building Maintenance Services of Government Buildings

Maintenance	**Code**	***Building Information Modelling***
YI – ECONOMIC ASPECT	X1.3	Information Data Requirement
	X2.1	Functionalities and Applications
	X2.2	LC Determination Against BIM Use
	X3.1	Method of Collecting Data
	X3.2	Modelling
	X3.3	Object Recognition
	X3.4	Utilization Strategies
	X4.1	Stakeholders Collaboration
	X4.2	Education & Training, Culture
	X4.3	Contract Relation
	X4.4	Applicable Law
	X4.5	Responsibility to Model
Y2 – TECHNICAL ASPECT	X1.1	*Industry Foundation Classes (IFC)*
	X1.2	*Model View Definition (COBie Standard)*
	X1.3	Information Data Requirement
	X1.4	Interoperability
	X2.1	Functionalities and Applications
	X2.2	LC Determination Against BIM Use
	X2.3	Accuracy and Capability
	X3.1	Method of Collecting Data
	X3.2	Modelling
	X3.3	Object Recognition
	X3.4	Utilization Strategies
	X4.1	Stakeholders Collaboration
	X4.2	Education & Training, Culture
	X4.4	Applicable Law
	X4.5	Responsibility to Model
Y3 – SOSIAL ASPECT	X1.3	Information Data Requirement
	X1.4	Interoperability

	X2.1	Functionalities and Applications
	X2.2	LC Determination Against BIM Use
	X2.3	Accuracy and Capability
	X4.1	Stakeholders Collaboration
	X4.2	Education & Training, Culture
	X4.3	Contract Relation
	X4.4	Applicable Law
	X4.5	Responsibility to Model
Y4 – ENVIRONMENT ASPECT	X1.3	Information Data Requirement
	X2.1	Functionalities and Applications
	X2.2	LC Determination Against BIM Use
	X4.3	Contract Relation
	X4.4	Applicable Law

After obtaining the BIM factor that influences the maintenance of the Government building, an analysis of the level of influence of the BIM factor on maintenance is observed. To determine the percentage of influence of each indicator, the measurement scale (Table 3) is required. By looking at the percentage of each indicator, then in the stage of data presentation can be known whether the indicator is very influential, influential, less influential, no effect, or very no effect on maintenance aspects of Government buildings, as shown in Figure 1.

Table 3. Measurement Scale

Score	Measurement	Percentage
1	Very no effect	0% - 20%
2	No effect	21% - 40%
3	Less influential	41% - 60%
4	Influential	61% - 80%
5	Very influential	81% - 100%

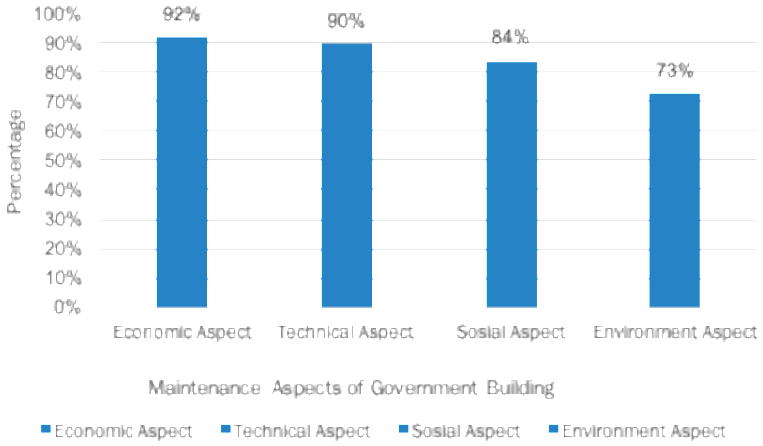

Figure 1. Level of BIM Effect on Maintenance Aspects of Government Buildings

By looking at the effect of BIM factors on the maintenance aspects of government buildings, not all the factors affect the aspects of maintenance. For the maintenance aspects of government buildings, the economic aspects, from 16 factors of BIM there are 12 factors that affect the economic aspects, with average percentage on the economic aspects is 92% (influential). Wiley (2011) also mentioned that one of the advantages offered by BIM is the reliability of the cost. Through BIM will certainly make it easier to estimate the cost based on the database owned by BIM.

While on the maintenance aspects of government building, the technical aspect, show that all BIM factors can affect the technical aspects of maintenance in Government buildings with the percentage 90% (influential). BIM factors

including information, functional, technical and organizational criteria, consisting of 16 sub-indicators, can affect the technical aspects. Similarly, GSA (2011) points out that integrated databases can store large amounts of project information, material quantities, installation dates, type of materials used in facilities, costs, schedules, etc. In other words, BIM has a great ability to facilitate a project and can serve as a single primary source for all project data.

In the social aspects of maintenance, there are 10 out of 16 BIM factors that affect the maintenance of Government buildings with an average effect of 84% (Influence). The organizational criteria contained in BIM can be said to be linear with the social aspects of maintenance. Thus these two indicators will affect each other. Same as the environmental aspect, the expert mentions that some BIM factors can affect environmental aspect of maintenance with the average percentage of 73%. Although only 5 indicators that could effect from 16 factors of BIM.

After found what factors affect the development of BIM-model to improve service on maintenance of Government buildings, both in terms of BIM criteria and also aspects of maintenance, the researchers conducted an analysis of how to develop the BIM-model in order to improve service in maintenance of government buildings. The object of case studies in this study is the existing building of government which previously has not done BIM modeling.

It has been mentioned previously that in order to develop a BIM-model to improve services in maintenance of Government buildings, it is necessary to consider the influencing factors of BIM (Table 2) as the basis for BIM development. And from these factors further as a reference to obtain data in the field, which where influential BIM factors are information, function, technical and organizational criteria.

However, from the results of the survey and in-depth interviews related to the object of this case study based on influential factors, obtained the result that:

- Maintenance and renovation work on Government buildings is done by partners (3rd party), so the building manager is limited to supervision and administrative.
- The data obtained in the field is quite limited, so the data information needs for BIM modeling can not be fulfilled

Given the findings obtained in this case study, the researcher proposes several steps that can be taken to use the BIM-model in improving services on maintenance of Government buildings based on the influential factors, as follows:

1. Knowing and defining function criteria of BIM
   In the utilization of BIM it is necessary to know the function and purpose of BIM first. Determination of BIM function is intended to make the utilization of BIM become more focused. Because by determining the function and purpose of BIM, then all the information and its supporting elements will be more clear.
   Based on the existing condition of the Government building, the building manager can determine the function and use of the desired BIM to help improve the service in the maintenance phase of the building. When a Government building wishes to utilize BIM in maintenance activities, it is necessary for the building owner to define the scope of the BIM scope. For example, does the BIM want to be used to improve services on maintenance of Government buildings?
2. Define the information criteria of BIM
   Based on the results of field survey, researcher found the phenomenon of limited data owned by the building manager (owner). And when the building manager wants to take advantage of BIM on maintenance, the manager of the building must have a BIM database that is adequate, easy and transparent in order to facilitate maintenance activities in government buildings. Based on the existing condition of Government buildings related to the availability of such data, in order to improve service on maintenance of Government buildings using BIM-model it is necessary to determine the required information criteria in BIM-model.
3. Knowing and determining technical criteria in using BIM
   After knowing the data needs of information desired by the building manager, the technical use of BIM can be determined to obtain the data and fulfill the BIM function itself. Considering that the Government building, which is the object of case study in this research, is an existing building that has not previously experienced BIM modeling, then the building manager can start by considering the right strategy how to get the desired data information needs.
   In general, data retrieval methods in the building eksisiting almost the same and can also use the research methods explained in this case study. After knowing the utilization strategy and the method used in data retrieval, BIM modeling is done based on the input that has been obtained from the previous data retrieval.

This modeling aims to facilitate the maintenance of buildings, especially visually. With the visualization of BIM-model will facilitate the building manager in identifying and analyzing related maintenance works. It also performed object recognition on each component in the BIM-model.

4. Conduct organizational and legal planning on BIM development
   Experts say that HR can affect the BIM by 70-80%. An activity certainly can not be separated from the role of stakeholders to achieve the desired goals. In order to achieve the desired objectives and functions of BIM, the building manager needs to anticipate related organizations. Starting from preparing the organization's ability to implement BIM, anticipating the collaboration of each stakeholder to support the utilization of BIM, as well as from the legal side related to the BIM model data and taking into account the applicable rules or standards.
   BIM is a tool and can also be said to be a process that can be used in maintenance of buildings. In order for BIM to be used / implemented properly and maximally by the organization or users who implement it, then the user must first understand and competent in the operation of BIM. This can be achieved through training to improve the competence of BIM users so that it will perform well. Collaboration/cooperation of stakeholders also greatly affect the implementation process in the organization, both internal and external organizations. Without the support of the owner, service providers, Government or other parties, the function and purpose of BIM would be difficult to achieve. So in the development of the BIM-model on Government buildings in maintenance also requires policy from the owner / building manager so that BIM-model development can be done.

4. Conclusion and Recommendation

The first objective of this research is to identify factors that influence the development of BIM-model to improve service on maintenance of government buildings. So it can be concluded from all the important factors of BIM, which have been validated by previous experts, that several factors of BIM are very influential on the economic aspects, technical aspects and social aspects of maintenance. While in environmental aspect of maintenance has percentage of influence equal to 73%, slightly lower than other aspects. Each influential factor can be seen in Table 2 with details as follows:

- 12 BIM factors that affect the economic aspects
- 15 BIM factors that affect the technical aspects
- 10 BIM factors that affect the social aspect
- 5 BIM factors that affect the environmental aspects

The conclusions can be obtained from the case study that the development of BIM-models to enhance service on maintenance of Government buildings is very new in Indonesia, although the use of BIM in other countries has been well developed. Until now the use of BIM in Indonesia is still done in several pilot projects at the stage of construction implementation, but has not entered the stage of maintenance yet.

Since BIM is still relatively new in Indonesia, so much still needs to be prepared in the future, both from the internal manager of the Government building itself and from external involving the support of Government and other parties. The first step that can be done to develop BIM-model in Government building is by preparing criteria through several stages in order to improve service on maintenance of Government building. The stages are to know and determine the criteria of the BIM function, determine the necessary information criteria, determine the technical criteria related to the BIM implementation and determine the appropriate organizational and legal criteria to support the BIM functions.

From the research results of BIM-model development to enhance service on maintenance of Government buildings, the suggested suggestions are as follows:

1. In further research it is necessary to know the right information system used in Government building to support BIM-model development
2. The constraints put forward by the authors are expected to be input or important note for further research related to maintenance of government buildings.

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