WEB-BASED BIM PROJECT EXECUTION PLAN MANAGEMENT SYSTEM (WeB-MaS) FOR PUBLIC WORKS DEPARTMENT MALAYSIA

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Dedicated to my lovely Heavenly Father,
Daddy, Mummy, Yi Lin, Zhi Peng, Chu Eng,
and my Hope companions.

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ABSTRACT

The effective uses of Building Information Modelling (BIM) Project Execution Plan (BPEP) are one of the success factors for a successful BIM implementation. However, a preliminary study with JKR indicated current BPEP preparation and management is inefficient and time-consuming due to the manual data entry. Furthermore, data inconsistency occurs due to the inability for real-time BPEP collaboration and updates as well as lack of BPEP document management. Hence, this research aims to develop a web-based BPEP Management System (WeB-MaS) for the case study research; JKR by improving the efficiency of BPEP preparation and management. The research's first objective which is to examine the user requirements of JKR for the development of WeB-MaS was conducted through a semi-structured interview with JKR BIM Unit. Consequently, to develop WeB-MaS as the second objective, Agile Scrum methodology was adopted. The last objective, which is to evaluate the user acceptance, usability, and advantage of WeB-MaS was fulfilled by conducting a questionnaire evaluation with JKR BIM Unit. WeB-MaS was designed according to JKR BPEP template with real-time element, ability to be in synced with mobile application, and accompanied with verification and review features. WeB-MaS received optimistic reviews by the JKR BIM unit and the system will be handed over to JKR. In regard to the concern on WeB-MaS security, future improvements will be made by migrating the WeB-MaS to JKR internal server. In conclusion, WeB-MaS ensures the quality of BIM information through BIM collaboration to improve productivity and efficacy of the BPEP preparation and management process.

ABSTRAK

Penggunaan *Building Information Modelling* (BIM) *Project Execution Plan* (BPEP) yang berkesan adalah salah satu faktor kejayaan bagi kejayaan pelaksanaan BIM. Namun demikian, kajian awal dengan JKR menunjukkan bahawa penyediaan dan pengurusan BPEP semasa adalah tidak cekap dan memakan masa kerana kemasukan data secara manual. Tambahan pula, ketidakkonsistenan data berlaku disebabkan oleh ketidakupayaan untuk kerjasama dan kemas kini BPEP dalam masa nyata serta kekurangan pengurusan dokumen BPEP. Justeru, penyelidikan ini bertujuan untuk membangunkan Sistem Pengurusan BPEP (WeB-MaS) berasaskan web untuk kajian kes; JKR dengan meningkatkan kecekapan penyediaan dan pengurusan BPEP. Objektif penyelidikan pertama iaitu untuk mengkaji keperluan pengguna JKR bagi pembangunan WeB-MaS telah dijalankan melalui temu bual separa berstruktur dengan Unit BIM JKR. Maka, untuk membangunkan WeB-MaS sebagai objektif kedua, metodologi *Agile Scrum* telah diterima pakai. Objektif terakhir iaitu menilai penerimaan pengguna, kebolehgunaan dan kelebihan WeB-MaS telah dipenuhi dengan mengadakan penilaian soal selidik bersama Unit BIM JKR. WeB-MaS telah direka bentuk mengikut templat JKR BPEP dengan elemen masa nyata, keupayaan untuk disegerakkan dengan aplikasi mudah alih, dan disertakan dengan ciri pengesahan dan semakan. WeB-MaS menerima ulasan optimistik oleh Unit BIM JKR dan system akan diserahkan kepada JKR. Berkenaan dengan kebimbangan mengenai keselamatan WeB-MaS, penambahbaikan masa hadapan akan dibuat dengan memindahkan WeB-MaS kepada pelayan dalaman JKR. Kesimpulannya, WeB-MaS memastikan kualiti maklumat BIM melalui kerjasama BIM untuk meningkatkan produktiviti dan keberkesanan proses penyediaan dan pengurusan BPEP.

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LIST OF ABBREVIATIONS

AEC	Architect, Engineering and Construction
AJAX	Asynchronous JavaScript and XML
BaaS	Backend-as-a-Service
BEP	BIM Execution Plan
BIM	Building Information Modelling
BIM-PIMF	BIM-project information management framework
BPEP	BIM Project Execution Plan
C&S	Civil and structural
CBMDM	Collaboration-based BIM Model Development Management
CD	Contect Diagram
CIDB	Construction Industry Development Board
CITP	Construction Industry Transformation Programme
CREaTE	Centre of Excellent for Engineering and Technology
CSS	Cascading Style Sheets
DBMS	Database Management System
DFD	Data Flow Diagram
EIR	Employer's Information Plan
HODT	Head of Design Team
HOPT	Head of Project Team
HTML	HyperText Markup Language
IAMTECH	Institute of Advanced Management and Technology
ICT	Information Communication Technology
IFC	International Foundation Class
IIBA	International Institute of Business Analysis
IPTA	Public University
JKR	Public Work Department
JPA	Public Service Department
IR 4.0	Forth Industrial Revolution

JS	JavaScript
JSON	JavaScript Object Notation
LOD	Level of Development
M&E	Mechanical and Electrical
MIDP	Master Information Delivery Plan
MoB-MaS	Mobile BPEP Management System
MOU	Memorandum of Understanding
NPM	Node Package Manager
MIS	Management Integration System
NBes	National BIM eSubmission
PAS	Publicly Available Specification
PBT	Local Authority
PC	Personal Computer
PDF	Portable Document Format
PHP	Hypertext Preprocessor
PIM	Project Information Model
PIP	Project Implementation Plan
QS	Quantity Surveyor
RAM	Random access memory
RFI	Requests for Information
ROI	Return of Investment
SDLC	System Development Life Cycle
SQL	Structured Query Language
SSD	Solid State Drive
SSR	Server-Side Rendering
STEP	Standard for the Exchange of Product Data
UAT	User Aceptance Test
UC	Use case
UI	User Interface
UX	User Experience
WeB-MaS	Web-Based BPEP Management System]
WPP	Superintendent (*Wakil Pegawai Penguasa*)

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CHAPTER 1

INTRODUCTION

1.1 Research background

The Fourth Industrial Revolution (IR 4.0) is riding the Digital Revolution wave in the construction industry. It has transformed the construction industry towards the direction of digitalization, automation, and the widening use of Information Communication Technology (ICT) (Alaloul et al., 2018). The adoption of Building Information Modelling (BIM) has revealed the benefit of digital information, which provides access to accurate and real-time data where technology and people are connected to boost the productivity of the construction industry in this era of digital revolution (Alaloul et al., 2020).

Accordingly, the director of Malaysia Public Works Department (JKR) introduced BIM implementation in 2007 to improve productivity and efficiency in delivering and managing construction projects in Malaysia (Latiffi et al., 2015). Through the Construction Industry Development Board (CIDB), JKR has driven the Productivity Thrust of the Construction Industry Transformation Programme (CITP) 2016-2020 to advance the digitalisation of the construction industry using BIM technology (BIM Day, 2019). Therefore, CIDB's myBIM Centre was established in 2016 to serve as a one-stop reference centre to support BIM adoption and development. The National BIM e-submission (NBeS) was also established to reduce the time it takes for the Local Authority (PBT) to approve a building plan process from 7-14 days in 2015 to 24-48 hours in 2020 (CIDB Malaysia, 2021). Currently, the government targets to reach 80% adoption of BIM system within the next five years through the CIDB's Construction 4.0 Strategic Plan 2021-2025 (Rashid, 2020).

BIM Project Execution Plan (BPEP) is considered as a key reference document, which outlines the details of the BIM implementation approach for contracting parties to deliver collaborative work practices in the BIM project (Messner et al., 2021). It provides a clear understanding of model exchanges, storage, naming conventions, and the organization of the model. It is also a dynamic document that requires to be updated from stage to stage (CIDB Malaysia, 2017a). There are two types of BPEP, namely Pre-contract and Post-contract. Pre-contract BPEP focuses on the process and methodology to deliver the information for BIM modelling practices during the design stage, while post-contract BPEP is used to coordinate and manage the information during the construction and operation stage (CIDB Malaysia, 2019).

BPEP is also considered as a part of the contractual document which prioritizes implementing BIM projects in JKR Malaysia. BPEP has made it compulsory for project team to prepare in accordance with the JKR BIM Guidelines Standards and work process (CIDB Malaysia, 2017a). All project teams should agree with BPEP at the beginning stage of BIM project. From the preliminary interview with the Head of JKR BIM Unit, JKR is currently responsible to prepare the pre-contract BPEP using Microsoft Word template for BIM government projects. Then, JKR will hand over the pre-contract BPEP to the main contractor for the preparation of their post-contract BPEP to coordinate and manage information during the construction and operation stage.

This research is significant in recognising the current practice and challenges encountered during BPEP preparation in JKR Malaysia. It is also an innovation to digitalise BPEP preparation and management in the database management system (DBMS). The findings will be significant in providing user requirements for developing a BPEP DBMS to improve the BPEP preparation and management in BIM projects in Malaysia. Therefore, this research will be conducted as a case study on JKR which aims to develop a web-based BPEP Management System (WeB-MaS) for JKR to improve the efficiency of BPEP preparation and management in JKR. The semi-structured interview will be conducted with JKR BIM Unit to achieve the research objective which is to examine the user requirements for the development of WeB-MaS. Then it is followed by the development of WeB-MaS using Agile Scrum methodology which relies on iterative development for building system features until the end product is developed. Lastly, the research also conducts evaluate the questionnaire survey for the third objective of evaluating WeB-MaS for JKR in terms of user acceptance, usability and system advantage.

1.2 Problem statement

The early development and effective uses of BPEP are considered to be one of the success factors for the successful implementation of BIM projects (Computer Integrated Construction Research Program, 2010). A well-implemented BPEP is typically available to every involved stakeholder where they are aware of their role and contribution, and strategic goal for implementation of BIM projects (Siresiya, 2019; U.S. General Services Administration, 2019).

JKR has developed a BPEP template in Microsoft word to prepare BPEP for the government BIM projects. However, the current practices of BPEP preparation using Microsoft Word template in JKR are inconvenient and time-consuming as reported by the Head of JKR BIM Unit during a preliminary interview. It requires manual data entry and the involvement of copying and modifying old BPEP documents in BPEP preparation (Lozinski, 2020b) which may cause a problem related to human error and degrade the quality of project information (Hamzah et al., 2018). The manual data entry in the Microsoft Word template is also inefficient which is time-consuming in BPEP preparation. Lin et al. (2016) also pointed out that BPEP preparation could cause the extension of the project schedule by two months. This is because there is only one BIM manager or BIM coordinator in preparing BPEP documents (Lozinski, 2020b). As a living document, BPEP requires a lot of effort from the BIM manager and is constantly updated manually, thus resulting in the inconsistency of data entry. Hence, the solution of BPEP form-filling template and real-time BPEP collaboration and update in web-based BPEP Management System (WeB-MaS) is introduced to address the research problem of inefficient and time-consuming BPEP preparation and management process caused by manual data entry of BPEP information.

In addition, BPEP is currently stored and retrieved in the file-based system. The file-based system has constraints regarding accessing privileges that cause poor data security that may risk unauthorized access and uncontrolled data redundancy (Coronel & Morris, 2018) in BPEP sharing and exchange among the stakeholders. Besides, there is less consistency in the file-based system which causes redundant data since the file system stores unstructured, often unrelated files (Peterson, 2022). Data inconsistency refers to a situation where there are various copies of the same data in different places that conflict with each other, wastes storage space and duplicate work (Watt & Eng, 2015). It is also the result of files created by different stakeholders from various departments over a long period within JKR. Moreover, it is also difficult to do real-time BPEP information updates and sharing when separate changes are made to files in a file system. The lack of real-time information leads to poor decision making where the guesswork is involved and further sets back the construction project (eSUB Inc., 2018; McKendrick, 2017). It delays the data availability according to the feedback of the head of JKR BIM Unit. The untimely and inadequate BPEP information also disturbs the process of BIM planning, control and decision making which make ineffective BPEP preparation process (Babaei & Beikzad, 2013). As a result, the lack of BPEP document control and database management challenges the current practices of BPEP in JKR Malaysia. Therefore, the solution of cloud database management system (DBMS) was proposed to address the problem of lack BPEP document management and inability of real-time update and sharing in this research. This solution allows JKR to create, manage and access BPEP data in the real-time database for real-time BPEP information update and sharing. It also promotes one-step approval workflow for BPEP verification and provides access control by regulating the security rule to BPEP projects which can greatly improve the quality and security of BPEP information.

Furthermore, to date, there is a lack of similar research related to BPEP database management system development in Malaysia. Previous studies (Ahmad et al., 2012; McArthur & Sun, 2015; Ramírez-Sáenz et al., 2018) focused on the BPEP development framework to improve BPEP development in the construction industry. These studies reviewed various BPEP templates in order to establish a new BPEP template and BPEP development framework for BIM implementation success. According to Bakar et al. (2020), the outline and elements in BPEP document are determined by BPEP developer according to their needs. JKR, the target of this case study, stated in a preliminary interview that the current JKR BPEP template document's BPEP outline and elements

(content) do not require improvement. It is because JKR has conducted a critical review of various BPEP templates from other organisations and developed a standard for JKR BPEP template development. However, there is a lack of improving BPEP preparation and management process amongst these studies. Thus, the research leads to the development of WeB-MaS in this research to bridge the gaps of improving the BPEP preparation and management process in JKR.

In summary, the issues encountered in current BPEP practice in JKR are inefficient and time-consuming BPEP preparation and update, lack of BPEP document management and the inability for real-time BPEP update. In addition, there is a lack of similar research related to BPEP database management system and a research gap of previous studies on BPEP preparation and management improvement nowadays. Hence, the case study research will be conducted on JKR BPEP practice and aimed to develop a web-based BPEP management system (WeB-MaS) that can strategically fill a research gap to improve the efficiency of BPEP preparation and management process for JKR projects in Malaysia.

1.3 Research aim and objectives

The research aims to develop a web-based BPEP management system to improve the efficacy of BPEP preparation and management process in JKR. The objectives of this research are to:

(i) Examine the user requirements for the development of web-based BPEP Management System (WeB-MaS),
(ii) Develop the web-based BPEP Management System (WeB-MaS) for JKR,
(iii) Evaluate the web-based BPEP Management System (WeB-MaS) for JKR in terms of user acceptance, usability and system advantage.

1.4 Research scope

This research seeks to develop a web-based BPEP Management System (WeB-MaS) for Public Works Department (JKR) Malaysia. It scoped to the case study on JKR organization to investigate current practices of BPEP preparation and management process and examine user requirements of WeB-MaS for JKR. The target respondents are restricted to the BIM unit of JKR as their crucial role and respondent in BPEP development. The research also only involves the pre-contract BPEP part as JKR is responsible for developing pre-contract BPEP for JKR BIM projects at the early planning stage, then handing it over to the main contractor for the post-contract BPEP preparation during the construction and operation stage. Besides, WeB-MaS is designed according to the previous JKR BPEP template 2019 for BPEP implementation in hospitals, institutions centres and education colleges in JKR BIM projects as shown in the list of JKR BIM projects in the 9th, 10th and 11th Malaysia Plans. Ya'Acob et al. (2018) also revealed that BIM implementation in Malaysia is considered more suitable for high-risk projects and complex projects. Thus, WeB-MaS application is suitable for BPEP implementation in high-risk and complex BIM projects.

In addition, Agile Scrum methodology is adopted for the development of WeB-MaS in this research. It is the combination of Agile philosophy and Scrum framework which is a project management approach that emphasizes an iterative and incremental development process. Agile Scrum methodology enables the development team easy and adapts quickly to the requirement changes even late in SDLC while waterfall methodology cannot accommodate changing requirements during the development process (Andry et al., 2019; Software Testing Help, 2019). It also requires the collaboration of self-organizing cross-functional teams, along with the product owner to determine what features to be done in each sprint (QualityLogic, 2022).

1.5 Significance of research

The development of a web-based BPEP Management System (WeB-MaS) for JKR is vital for the fact that it can enable the enhancement of BIM technology with the ultimate aim to improve the confidence of project stakeholders in a construction project. It strategically bridges the research gap of previous studies on BPEP preparation and management process improvement. The research provides a BPEP database management

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