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The Effect of Project and Programme Reference Models in Architecture, Engineering and Construction (AEC) System Development

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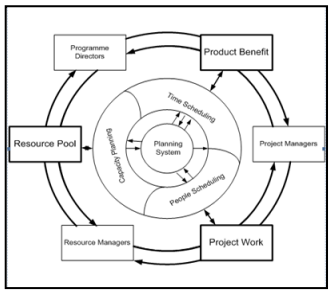

Abstract

This paper presents the effect of project and programme reference models in Architecture, Engineering and Construction (AEC) system development. The trend towards AEC projects becoming more globalized, with multiple projects and processes being conducted concurrently, requires information systems to be widely implemented in the industry. However, current information systems tend to be specific and individually-centred offerings. Also, the existing knowledge for the implementation of information system integration is not helpful because different organizations have different characteristics regarding work, information, processes, culture, and ideas. To address these issues, research was conducted to review the existing information system models which can be apply to construction project and programme management and their effects on developing an information reference model for an AEC information system. The reference model can be used as guidelines for developing a standardized information system for enterprise project management with information integration practice for various organizations. The model can also be used to outline software requirements in the process of selecting a project and programme management software system in the market. Thus, adoption of this reference model as an essential foundation will affect the data management, knowledge management, information analysis and sustainability aspects in AEC system development.

Keywords: Project management; knowledge management; information technology; reference model; guidelines

1.0 INTRODUCTION

Construction projects have grown larger and more complicated nowadays. Multiple projects run concurrently are typical in major Architecture, Engineering and Construction (AEC) organizations. As projects have become larger, technical complexity has become greater. Project requirements have increased, Client demands and government regulations have grown considerably and public desire for an improved lifestyle quality has increased.

To add another layer of complexity, Organizations are urged to incorporate sustainability as a major objective into their construction process in construction management (Rawai *et al.*, 2013a). The PMI project management standard by, PMBOK 5th edition, redefined the Data, Information, Knowledge and Wisdom (DIKW) model to be used in the field of Knowledge Management, which mean a project data and information flow need to be more consistence and aligned with DIKW (PMI PMBOK, 2013). Sustainability in the process of designing, planning and developing process become a critical factor as they become one of the elements in the wisdom aspect of construction management (Fathi *et al.*, 2012). The most common issue identified in construction management is related to Integrations between project parties, including documentation, communications, and interoperability. Because of the dynamic environment in construction information and the participation of multiple parties, collaborative and integration teamwork is important to the construction industry (Nourbakhs, 2012). With the development of Information Computer Technology (ICT), the construction industry has a great potential to increase the effectiveness of information management between project parties. Computerized information systems in the construction industry have been built purposely to integrate the information and data, processing and transferring that information so that stakeholders can obtain a clear view of the project operations that they are managing (Zakaria, 2012).

Therefore, to manage the huge influx of project information, an integrated and computerized project management information system (PMIS) is required. The PMIS

has been identified as the tool to achieve the objectives of better collaboration and integration among projects (Rawai *et al.*, 2013a).

However, despite the many benefits of these technologies and all the efforts that have been put into developing and facilitating the information system in AEC projects, utilization of this technology has not significantly progressed beyond simple document storage and exchange, file management and single function databases (Sumner, 1999; Karim, 2011; Rawai *et al.*, 2013a). A good PMIS should provide an individual satisfaction to the users, also provide an organizational satisfactions, such as adhering to the project budget, schedule, and specifications (Raymond and Bergaron, 2008). This impact seems to be lacking in available PMISs today. Drawbacks of the current system can be characterized as follows:

Complex system–Increased complexity in the system leads to uncertainties of what type of information, what format and to whom or when this information need to be delivered by project team/workers (Elonen and Artto, 2003).

Information overload and big data–Too much information causes problems for the system in identifying and selecting the relevant information from an abundance of available information and will **increase** the time for information processing (Caniëls and Bakens, 2012; Zakiyudin *et al*., 2013). Eventually, this process will cause fragmentation in the system.

- Usability, compatibility–As an information system passes through layers of technology transfer, the original features become distorted (Anna, 2011). Systems should adopt a computing standard which allows it to be compatible with the changes of technology (e.g.: cloud computing, mobile computing).
- Standardization, integration and coordination–An individually designed PMIS can create an inefficient and disintegrated system. A PMIS with a standardized format and definitions that everyone can learn to understand increases understanding, saves time, and helps create an integrated system (Anna, 2011).

In addition, the growth of technology, especially mobile communications and social networks, in recent years should be adhered. Mobile features in the system or software have become a necessity in today's environment. The AEC industry has greatly benefited from the advances in mobile communication technologies, Mobile project management information systems have increased the speed of information flow and collaboration (Fathi *et al.*, 2012), enhanced the efficiency and effectiveness of information communication (Gumm *et al.*, 2005), and reduced the cost of information transfer.

There are several factors that contribute to the problems in existing AEC project management information systems (Rawai *et al.*, 2013b):

1. They do not fit user requirements,
2. They do not follow standards,
3. They do not have guidelines for the development process.

However, all the above issues can be countered by the adoption of appropriate reference models in the process of developing the integrated system. This will be further discussed below. The review is of available reference models for project management that cover all the management levels in managing a project and a comparison of the models.

This paper consists of 6 sections. The next section will discuss the reference models, their history and specifically focus on the information reference model. The third section will review previous projects and a programme reference model that been applied in AEC system development in recent years. In section 4, the comparison of the existing reference models was carried out and discussed. The effect of adopting the reference model in AEC system development is then discussed in section 5. Finally, in section 6, the research conclusion is drawn.

2.0 REFERENCE MODELS

Information systems (IS) are technical systems with social consequences (Hirschheim *et al.*, 1995; Karim, 2011). They comprise people, software, procedures, hardware and the organizational system. This is why information reference models is important in the analysis, design and deployment of information systems (Fettke and Loos, 2003). Three types of information models can be defined depending on the phase or level of design and implementation in IS (Ahlemann, 2009):

1. **Conceptual models** help with the requirements that IS need in terms of documenting, analysing, and understanding of the requirement. These models focus on the solutions for the problems or the supports for specific processes and do not take any technical aspects into consideration.
2. **Design models** specify the component of architecture for information system by describing larger technical building block. However, this component are not analysed in detail.
3. **Implementation models** depend on specific technologies and are closely related to software programming.

Luiten *et al.* (1993) was first used the term ''reference information model" when they combined their individual research activities on modelling in the architecture, engineering and construction domains. As a result, they create IRMA (Information Reference Model for AEC), an unified domain model (Luiten *et al.*, 1993). Reference models are one alternative approach to help speed up the development of enterprise-specific models (Fettke and Loos, 2003). Reference models provide a basis for the design of organisation and application systems for companies and researchers (Thomas, 2006). Thus, this research will review and compare the available project management reference models and show the gaps in the existing models that will be fulfilled by the new concept of a reference model.

3.0 PREVIOUS PROJECT AND PROGRAMME MANAGEMENT REFERENCE MODELS

Froese (1992), produced a "standard model" as one of the important reference information models for project management in the AEC industry. Using object-oriented modelling techniques to develop a domain model for project management and a corresponding application system. This was followed by Sacks (2002) who developed an integrated AEC information service using object methods and a central project model. Both models were designed for a single-project management system.

The first reference information model for programme management was published by Turner and Speiser (1992). This model needs objectives coordination of programme directors, project managers and resource managers. This model shows that all information required by these three sets of manager can be met by an integrated system, as shown in Figure 1. This integrated system consist of three major elements (Turner and Speiser, 1992) as follows:

- A master project scheduler (MPS): To manage the priorities between projects and to assign resources to individual projects by programme directors;
- Traditional project-management systems: Conventional ways (using the assigned resources) to deliver individual project objectives, using the assigned resources by project managers; and
- People schedulers: To assign people to the multidisciplinary teams working on projects, within the constraints set by the programme directors, but meeting the objectives of the project managers). This is use by resource managers.

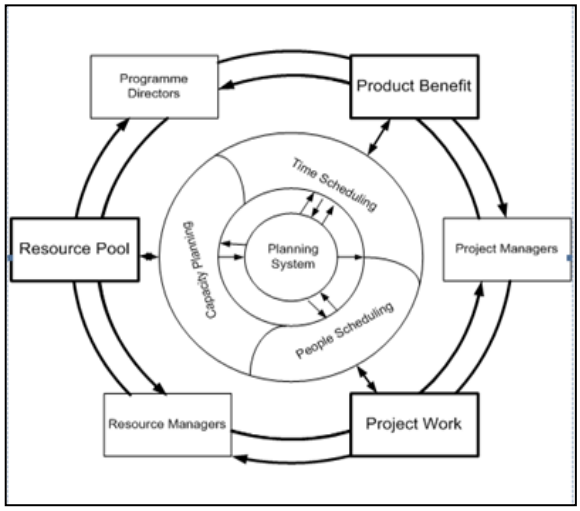

Figure 1 Information-systems requirement of programme management (adopted from Turner and Speiser, 1992)

Ahlemann (2009) presented an enterprise-wide project management reference information model that covers all project management processes in terms of projects planning, coordinating and controlling. As shown in Figure 2, based on the literature and empirical research, RefMod[PM], provide validated process and data structure descriptions for project management (Ahlemann and Riempp, 2008). The model can also be adopted in the design process for software in project management and to set-up the surrounding organizational system, also to define the software requirements that are essential in selecting an organization specific project management software system. RefMod[PM] covers both single-project management and multi-project management. It is called M-Model that based on a single, uniform, information system architecture and makes use of the Unified Modelling Language (UML) Version 2.

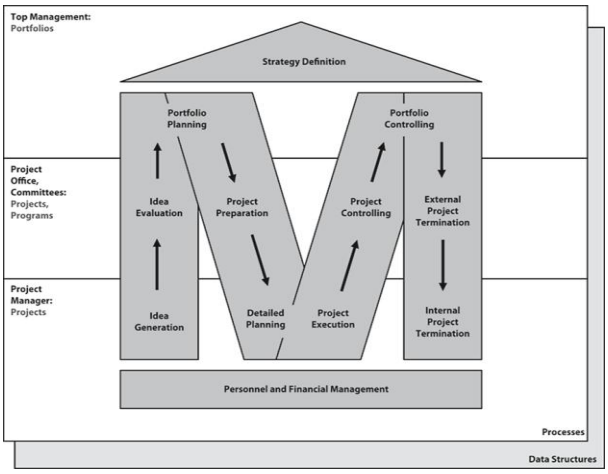

Figure 2 The M-Model (Ahlemann, 2009)

As shown in Figure 2, The M-Model in RefModPM is specified project life-cycle phases outlined in its scope to ten activity diagrams. A class diagram that describes the data structures required to support the respective processes has assigned to each of these activity diagrams. The activity diagrams are further refined in more detailed process descriptions, where necessary.

4.0 COMPARISON OF THE REFERENCE MODELS

Based on the previous and current project management information system review, Table 1 compares four project and programme management information system reference models intended for construction management. Based on the research study by Ahlemann (2009), and for the purpose of comparison, to find the most suitable project or programme management information system model to be adopted in managing a construction project, the following general requirements were adopted:

1. PMIS models must clearly identify the applicability of the model to a project life-cycle phase or project status;
2. For the purpose of multi-project management, PMIS models must identify the project's information in a hierarchical system (project, programme or portfolio level); and
3. PMIS models must be identified for the topic covered by the Project Management Institute (2004) which according to the nine knowledge areas of the Project Management Body of Knowledge (PMBOK).

Based on the comparison in Table 1, it is clear that the RefMod[PM] model is overly achieved the scope of previous reference models. However, since RefMod[PM] adopted some ideas from previous models and modify them to address the additional requirements, this is not surprising result. Table 1 also represents RefModPM's significant research progress in the field of PMIS reference models. RefMod[PM] has significantly wider scope that cover project planning, execution, initiation and benefit realisation) and designed to be able address both single- and multi-project management; and also covers all functional areas of PMI's PMBOK 3rd edition.

Table 1 Comparison of project and programme management information system reference model

	Froese Model (Froese, 1992)	Turner and Speiser Model (Turner and Speiser, 1992)	Sacks Model (Sacks, 2002)	RefMod^{PM} Model (Ahlemann, 2009)
Domain Characteristics				
Programme lifecycle phases	Planning.	Identification, Planning, Delivery, Closure.	Delivery.	Identification, Planning, Delivery, Closure.
Management levels	Project.	Project, Programme, Portfolio.	Project.	Project, Programme, Portfolio.
Supported industries	Construction Industry.	Many Industries such as IT, Architecture, Engineering, Construction and Aerospace.	Building Information.	Many Industries such as IT, Architecture, Engineering, Construction and Aerospace.
Topic Covered (According to the nine knowledge areas of the Project Management Body of Knowledge (PMBOK)(Project Management Institute, 2013)				
Integration management	No	Yes	Yes	Yes
Scope management	Yes	Yes	No	Yes
Time management	Yes	Yes	Yes	Yes
Cost management	Yes	Yes	Yes	Yes
Quality management	No	Yes	No	Yes
Human resources management	No	Yes	Yes	Yes
Communications management	No	Yes	Yes	Yes
Risk management	No	No	No	Yes
Procurement management	Yes	No	Yes	Yes
Project Stakeholders management	No	No	No	No
Models available for:				
Data structures	Yes	No	Yes	Yes
Organizational structures	Yes	No	No	Yes
Processes	No	Yes	Yes	Yes
Information management	No	No	No	No
Knowledge management	No	No	No	No
Wisdom	No	No	No	No

■5.0 EFFECTS OF REFERENCE MODEL ADOPTION IN AEC SYSTEM DEVELOPMENT

The implementation of an efficient project management information system with the right reference models can improve the efficiency of information flow in current information systems for the construction industry. The important characteristics of an improved information flow system in project management is to provide an real time and up-to-date organisational structure that will reduce the problems of multiple agents and hierarchies (Šuman and Pšunder, 2008).

Through this research, we hope to be able to contribute by providing significant insights into why a reference model is an essential foundation to help a programmer or project and programme manager to develop an effective and efficient information system by providing appropriate guideline systems. Integrating and standardising systems is strategically demanding today, therefore, having a reference model that complies with the global standard-the PMI's PMBOK (PMI, 2013)-will greatly benefit the developer. In addition, this reference model helps the developers to anticipated a potential problems and create solutions in their information system development. By adopted the idea of using an appropriate reference model in AEC system development, most of the problems can be dealt with including the complex and fragmented system, standardization, integration, co-ordination and collaboration issues in the current system (Ahlemann, 2009; Fettke and Loos, 2003).

This reference models is an essential foundation for helping a programmer or project and programme manager to develop an effective and efficient information system, which will be able to provide guidelines for programmers to develop other systems (Fathi, *et al.*, 2009; Ahlemann, 2008). By visualizing the important elements in development process, they can have a clear view of the system and the chances of producing an effective and personalised system or software are much higher. Plus, the system can be developed according to the PMI's PMBOK (Project Management Institute, 2013) standard. This will give an advantaged to the system in terms of compatibility with their other organisational systems or software and even with different organizations (Ahlemann, 2009; Fettke and Loos, 2003). In addition, Integrations between systems can be achieved by having a solid foundation and guidelines throughout the development process. This will help the information system developers concentrate on potential problems and provide solutions in terms of organizational structures, reengineering business processes, and information management (Ahlemann, 2009).

Thus, the improved and efficient construction project management information system may be able to address the following by adoption of the appropriate reference models in the

development process (Raymond and Bergeron, 2008; Caniëls and Bakens, 2012; Karim, 2011):

1. Improved and more timely decision-making;
2. Improved efficiency in managerial tasks to provide a better project planning, scheduling, monitoring and control;
3. Provide the construction project and programme managers a tool or a system that enables them to monitor, access and control the specific project information across all projects, and ensure that the project stays within the overall strategic objectives of the organisation.
4. Improve the ability to make an instant decision based on the instant access to real time information;
5. Improve the efficiency and reliability of information in existing information systems;
6. Improve coordination and communications between the project team; and
7. Improve control on budget and project deadlines at the same time able to fulfilled technical specifications.

6.0 CONCLUSION

This paper presents the effects of project and programme reference models on AEC system development. The current practices in developing a system or software in the AEC industry were missing an important element i.e. the reference models. The current project management information system (PMIS) offers limited benefits which are less than those set out in its intended objectives. In the AEC industry where the information management is vital, adoption of the best PMIS is important. To come up with such a system, various aspects and elements in the developing process should be considered. Therefore, reference models offer the best solution. Without appropriated reference models, the system will be developed without appropriate guidelines and eventually, will suffer from standardisation and coordination issues. Moreover, the system will be unable to integrate with other systems and software and adding new modules could be impossible. Also, complex construction that generated information overload could finally fragment and damage the whole system. The application of the previous reference models validates the concept and utility of the model, showing it to be useful and necessary for developing a standardized and integrated project management system.

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