EXECUTIVE INFORMATION SYSTEM FOR MONITORING BUILDING CONSTRUCTION WORK PROGRESS

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To my beloved mother and father

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ABSTRACT

Progress monitoring and control is one of the most important tasks when managing a project. Basically, construction works produce a lot of information and it is the responsibility of the top management to track the work progress at project site. A recent issue highlights inefficiency in obtaining information from site on time. Hence, the focus of this research is to establish a computerized information system which can be utilized by the top management in order to evaluate the construction progress. The aim of this research is to propose a model and develop a computerized project progress monitoring system, known as Executive Information Site Monitoring System (EISMS). Before developing EISMS, current problems faced by the top management in monitoring work progress and various models for construction monitoring in Malaysia Construction Industry were investigated through a questionnaire survey. It was found that manual data collection, time consuming report making, and no on-time corrective actions are current problems incurred by the top management in Malaysia. Indeed, monitoring of work progress depends on a combination of three methods; taking pictures from construction processes, having a database, and using planning software such as Microsoft Project (MS Project). EISMS was developed based on the Waterfall Model and the process began by identifying system requirements, system analysis, system designs, coding, integration and finally system testing and implementation. The system requires three primary data which include; planned work schedule, 3DCAD drawing, and actual work completion at site. From these three parameters, the system is able to compute scheduled and actual work progress and hence schedule variance at any selected evaluation date. In conclusion, EISMS was successfully implemented during construction phase allowing the top management of construction organizations to monitor the construction site progress more efficiently, which helps them in decision making and taking timely appropriate action.

ABSTRAK

Pemantauan kemajuan serta kawalan selia kerja merupakan salah satu tugas yang paling penting apabila menguruskan satu projek. Pada asasnya, kerja-kerja pembinaan menghasilkan banyak maklumat dan ia adalah tanggungjawab pengurusan atasan untuk mengesan kemajuan kerja di tapak projek. Isu baru-baru ini menonjolkan ketidakcekapan dalam mendapatkan maklumat dari tapak pembinaan pada masa yang ditetapkan. Oleh itu, tumpuan penyelidikan ini adalah untuk mewujudkan satu sistem maklumat berkomputer yang boleh digunakan oleh pihak pengurusan atasan bagi menilai kemajuan pembinaan. Tujuan kajian ini adalah untuk mencadangkan model dan seterusnya membangunkan sistem pemantauan projek kemajuan berkomputer, yang dikenali sebagai Sistem Maklumat Eksekutif Pemantauan Tapak (EISMS). Sebelum EISMS dibangunkan, masalah semasa pengurusan atasan dalam pemantauan kemajuan kerja-kerja dan model-model pemantauan pembinaan dalam industri pembinaan di Malaysia telah disiasat melalui kajian soal selidik. Hasil soal selidik mendapati bahawa pengumpulan data secara manual, masa yang panjang untuk membuat laporan, dan tiada tindakan susulan pembetulan yang cepat adalah masalah semasa yang di hadapi pengurusan atasan di Malaysia. Kerja-kerja pemantauan kemajuan kerja bergantung kepada gabungan tiga kaedah; gambar proses pembinaan, mempunyai pangkalan data, dan penggunaan perisian perancangan seperti Microsoft Project (Projek MS). Proses pembangunan EISMS berasaskan model 'Waterfall' dan ia bermula dengan mengenal pasti keperluan sistem, analisis sistem, reka bentuk sistem, pengaturcaraan, integrasi dan akhirnya ujian dan pelaksanaan sistem. Sistem ini memerlukan tiga data utama iaitu perancangan jadual kerja, lukisan 3DCAD, dan kerja siap sebenar di tapak. Daripada tiga parameter ini, sistem tersebut berupaya memproses pengiraan kemajuan kerja jadual yang di rancang dan kemajuan kerja sebenar; dan seterusnya jadual varian pada mana-mana tarikh penilaian yang dipilih. Kesimpulannya, EISMS telah berjaya dilaksanakan membolehkan pengurusan atasan organisasi pembinaan untuk memantau kemajuan pembinaan di tapak dengan lebih cekap serta membantu mereka didalam membuat keputusan serta mengambil tindakan susulan awal.

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LIST OF ABBREVIATIONS

AC	-	Actual Cost
ACAD	-	AutoCAD
ACWP	-	Actual Cost of Work Performed
AEC	-	Architect, Engineering, Construction
ARM	-	Activity Relationship Matrix
BAC	-	Budget at Completion
BCSW	-	Budgeted Cost of Work Scheduled
BCWP	-	Budgeted Cost of Work Performed
BQ	-	Bill of Quantity
Brep	-	Boundary Representation
CSG	-	Solid Geometry
CAD	-	Computer-Aided Design
CADD	-	Computer-Aided Design And Drafting
CIC	-	Computer-integrated Construction
CIDB	-	Construction Industrial Development Board
CPI	-	Cost Performance Index
CPM	-	critical path method
CPU	-	central processing unit
C/SCSC	-	Cost/Schedule Control Criteria
DBMS	-	Data Base Management System
DoD	-	Department of Defense
DSS	-	Decision Support System
EAC	-	Estimate at Complete
EIS	-	Executive information system
EISMS	-	Executive Information Site Management System

ETC	-	Estimate to Complete
EV	-	Earn Value
EVM	-	Earned Value Method
HAN	-	Home Area Network
HOPT	-	Head of Project Team
IDE	-	Integrated Development Environment
ISDN	-	Integrated Services Digital Network
ISO	-	International Organisation for Standardisation
IT	-	Information Technology
JIF	-	Java Inspection Framework
KBMS	-	Knowledge Base Management System
KPI	-	Key Performance Indicator
LAN	-	Local Area Network
MAN	-	Metropolitan Area Network
MCI	-	Malaysian Construction Industry
MIS	-	Management Information System
NSIA	-	National Security Industrial Association
PC	-	Personal Computer
PKK	-	Pusat Khidmat Kontarktor
PMB	-	Performance Measurement Baseline
PPMS	-	Project Performance Monitoring System
PV	-	Plan Value
QBE	-	Query-by-example
RDBMS	-	Relational Database Management System
RI	-	Relative Index
RM	-	Ringgit Malaysia
SAGE	-	Semi Automated Ground Environment
SMM2	-	Standard Method of Measurement
SQL	-	Structure Query Language
STEP	-	Standard for the Exchange of Product Model
SVM	-	Support Vector Machine
S.O	-	Superintending Officer
TPS	-	Transaction-Processing Systems

VAC	-	Variance at Completion
VB	-	Visual Basic
VIRCON	-	Virtual Construction
WAN	-	Wide Area Network
WBS	-	Work Breakdown Structure
XML	-	Extended Markup Language
2D	-	Two-dimensional
3D	-	Three-dimensional

LIST OF SYMBOLS

$	-	Dollar value /USD (Refers to the cost)
£	-	British pound(Refers to the cost)
U	-	Mann Whitney U

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CHAPTER 1

INTRODUCTION

1.1 Introduction

It is widely recognized that construction is an information intensive and complex industry. Effective and systematic monitoring and control of information flow is a critical ingredient throughout the life-cycle of construction projects. Harris and McCaffer (2001) described monitoring as an act of checking actual progress, actual resource usage and taking decisions to alter the likely future outcome, while control is completing the project on schedule. Hinze (1998) described monitoring as recording the actual start and finish dates for activities while the project is underway, and control relates to the analysis of the impact of any schedule deviations and evaluation of what remedial actions should be taken.

To effectively monitor a project, an organization should have a system that is able to provide critical information whenever it is required and share the information from a single source within the organization to support its daily operations and decision making. Development of Information Computer Technology (ICT) has enabled the construction industry to increase the efficiency and effectiveness of information exchange between head office and site office. Lock (1993) highlighted that the purpose of computer based information systems in the construction industry is to integrate the collection, processing and transmission of information so that engineering professionals can gain additional insight into the operations they are managing.

A different class of computer applications for monitoring and evaluating construction projects have been developed including ‘Visual Inspection’ model by Silva *et al.,* (2009), DCM by Memon (2006), PPMS by Cheung *et al.*, (2004), PHOTO-NET II by Abeid *et al.* (2003), VIRCON by Dawood *et al.* (2002), ESCAAD by Wang (2001), DIPAP by Streilein (1996) and CADCIMS by Stumpf (1995) which replace traditional monitoring methods. In traditional monitoring method, the project progress is reported based on project manager’s diaries, daily site records and other documents that transmit paper-based data, contributing to errors and the inefficiency of site information communication and exchange.

1.2 Background of Study

The invention of Information Technology (IT) in this century is responsible for developing the concept of Management Information System (MIS) in organization management. MIS manages information flow allowing individuals to complete their daily work duties. At the Executive management level, making decisions is a daily duty, and these management decisions affect the organization’s performance. Thus, as a key component of decision making, reliable information must be provided to Executive management in a proper manner, and acceptable quality, if it is to enhance organizational performance. Executive Information System (EIS), as Decision Support Systems (DSS) were introduced in the early 80’s. In general, EISs are enterprise-wide decision support systems (DSS) that help top-level executives to analyze, compare, and highlight trends on important variables so that they can monitor performance and identify opportunities and problems. EIS and data warehousing technologies are converging in the marketplace. Turban and Aronson (2001) described an EIS as “computer-based system that serves the information requirements of top executives. It provides rapid access to timely information and direct access to management reports. Apart from being user friendly, EIS can be supported by user graphics providing exceptional reporting and drilldown capabilities. It can also be connected to the Internet, Intranet and Extranets".

Several studies conducted on EIS have highlighted various keys issues. Kaniclides and Kimble (1995) carried out a research on "A Framework for the Development and Use of Executive Information Systems". They concluded that clear knowledge in EIS is essential before developing the system. Other research done by Young and Watson (1995) on "Determinates of EIS acceptance" proved that EIS is difficult to use and may fail but ease of use alone does not ensure acceptance. Ong *et al.* (2005) published "Revitalizing Executive Information System Design and Development" proving that EISs have uncertain characteristics that are impractical for individual executives. Jirachiefpattana (1997) studied "The impacts of Thai Culture on Executive Information Systems Development" and found that EIS should be created only if the users want to be involved in its development process to avoid failures.

1.3 Problem Statement

Top management of a growing organization can become separated from the mainstream of the organization to such a degree that the indicators of trouble become invisible to them. Contractors take so much workload and have very little time to manage well and no time to plan or review progress or performance. They never step back to see how the company is doing, and to get an overall picture of the project. Other contractors are unaware of trouble signs because their middle managers do not report to them, and top managers of large companies cannot observe all details at all times. They are great at putting construction in place but not skilled at overseeing the business and being alert to subtle changes that can affect it (Schleifer 1990).

Top management also has to make important decisions that can have a significant impact on the company. At project level, matters that concern top management amongst others are rate of productivity of work progress, work completion, certified works and paid works. Top management monitors work completion because it directly affects profit, where delay causes losses to the company. Schleifer (1990) stated that rate of productivity of work on the other hand can identify potential problems that may exist on site while certified works and paid works have a bearing on cash flow and tax structure of the company. All the above information needs to be supplied to top management in the quickest and simplest possible form.

Therefore, there is a need for contractors to be aware of work progress on site. It is also important that the vast amount of information from site is presented in the simplest possible form at head office so that the busy top management can digest and understand this information easily and effortlessly. This can be achieved by having an information system which can ultimately produce a 3D visual presentation model of the work progress on site together with analysis of its performance.

This system will be a tool for the top management, allowing them to have an independent information system. Knowing that the top management has an independent tool to verify their reports, project managers will work more diligently. This system will be expected to help top management make better decisions. At the end of this study, the system developed will be able to assist top management to easily monitor and evaluate the project performance, and to quickly and accurately pursue for successful completion of construction work according to clients' demands.

1.4 Aims and Objectives of Study

The aim of the research is to develop an Executive Information System for monitoring construction work progress (named 'Executive Information Site

Monitoring System'-EISMS). The system shall be able to analyse data obtained directly from site and to provide information to top management. It provides customised information required by top management to make decision. The system shall also serves as a checking or validating tool for top management when reviewing reports from project managers at site or from projects department at head office. By having such a system, top management is able to digest the status of work progress at site almost instantaneously. The system shall avoid using complicated integrated software system because it requires different skills to handle which in turn will involve many different departments. It should be a user friendly system, easy to install and to maintain. Thus, to achieve the final outcome of this research, the following step related objectives have been identified;

Objective1: To identify problems faced by top management to monitor construction work progress.

Objective2: To identify key performance indicators needed by top management to monitor construction work progress.

Objective3: To investigate and identify various models for construction monitoring in Malaysia Construction Industry (MCI).

Objective4: To investigate and identify Executive Information System feature requirements for development of Executive Information System.

Objective5: To develop an Executive Information System to monitor construction work progress.

Objective6: To validate and verify the developed Executive Information System.

1.5 Scope and Limitation of the Study

For the development of this new information system so called EISMS, the performance measurements to be analyzed in this study shall focus solely on the physical work completion at site. Other performance measurements, like resource productivity and which includes such things as material on site, labour, machinery and plants are not within this scope of study. The research is to improve efficiency in performance monitoring and not other scopes like improvement in scheduling, workers satisfaction and data acquisition.

The sponsor of the research has involved in many building projects and has interest in improving building construction. In line with that the research has focus more on developing a system for a building construction.

The research limits its scope to produce a software prototype to illustrate the workability of the system proposed and not a product up to commercial level. As such the case study selected for testing the prototype shall be limited to a simple and small building project with a construction price of not more than RM5 million.

1.6 Significance of the Research

Basically, construction works produce a lot of information that is required by the top management to track the work progress at site. The executive information system can improve top management's ability to monitor, coordinate and control the operation of an organization efficiently and to streamline the process of accurate decision making. This is because the system provides top management with high quality, timely, relevant, and relatively complete information. Apart from acting as a validating tool, EISMS can also play the role of a second source of information to top management. This role can be depicted in the flow chart as shown below:

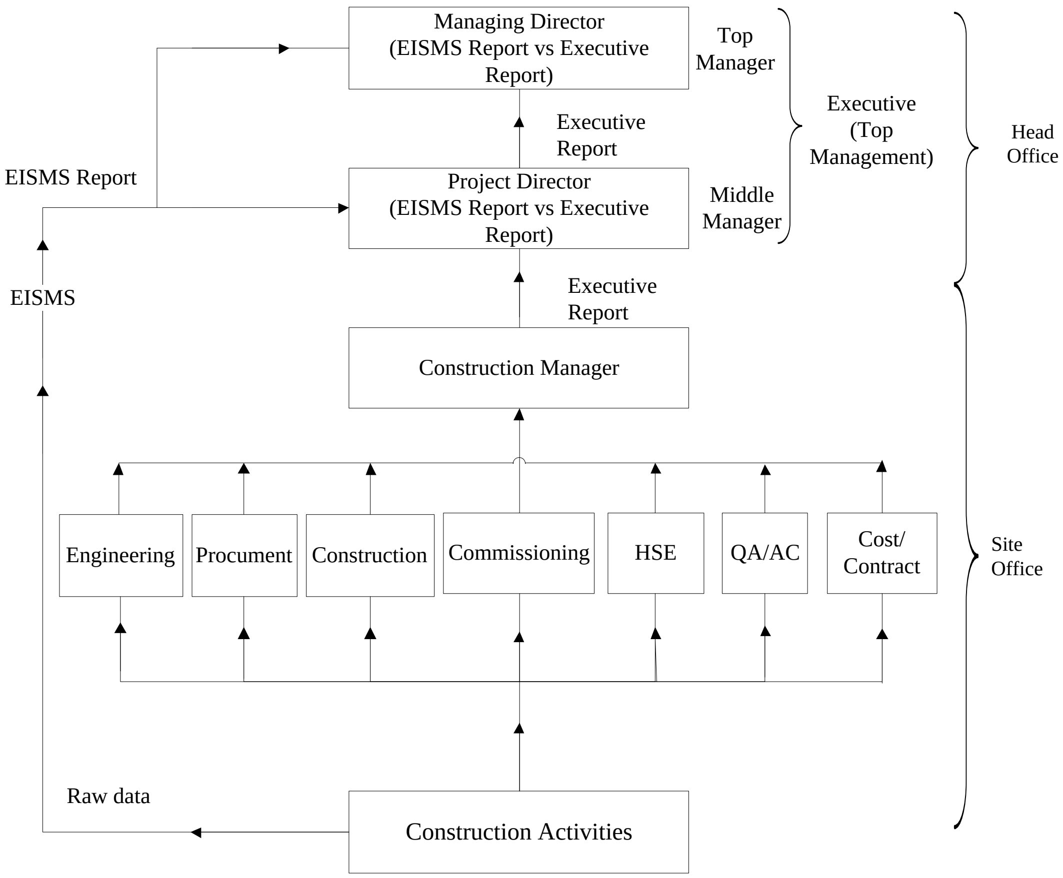

Figure 1.1: Role of EISMS

1.7 Research Methodology Framework

Preliminary understanding of the research subject was obtained through several discussions with personnel whose have more than fifteen years in construction work followed by intensive literature review on various topics. A close-end questionnaire was designed for this research. The questionnaire was divided into five different sections corresponding to objectives of the research. Likert Scale method was selected to measure the variable data. The final developed questionnaire survey then was sent to contractor companies selected randomly from a list provided by the Construction Industry Development Board (CIDB) Malaysia; these companies were registered under building contractor of Grade VII (PKK Class A Contractor). Apart from the questionnaire survey, several face to face interviews were also carried out. The data collected from the survey were then analyzed using average index method for result and discussion.

From the discussions with the experience personnel, an intensive literature review and questionnaire survey, the system requirements for EISMS were established and from there, EISMS was developed based on Waterfall Model. To validate and test the EISMS, the complete developed prototype was used to monitor an actual construction building work in Selangor, Malaysia. Upon successful validation and verification of EISMS prototype, the research was concluded. A flow chart showing the process of the research methodology is presented in Figure 1.2.

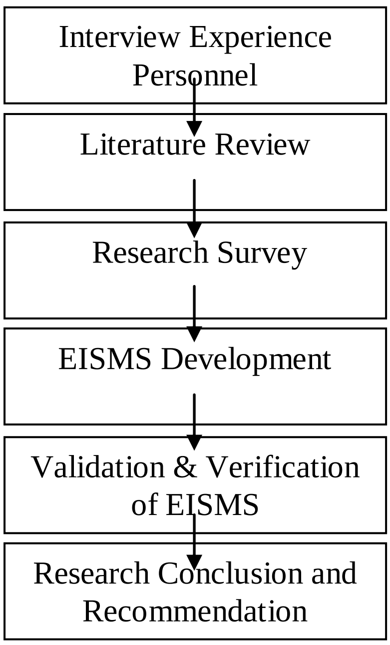

Figure 1.2 Research Methodology Frameworks

1.8. The Organization of Thesis

This research is presented into eight chapters as follows:

Chapter 1: Introduction; This chapter briefly discussed the introduction to the research topic, which is the development of an Executive Information System (EIS) to monitor construction work progress. This chapter furthermore outlined the background of the study, problem statement, aim and objectives, scope and limitations of the study, significance of the research, research methodology framework and the organization of the thesis.

Chapter 2: Construction Monitoring Problem and Its Performance Measurement; This chapter reviews the main subjects related to the research topic namely monitoring in construction, advances in information technology, an executive information system and level of management in a construction organization. This chapter also reviews various topics related to the first two objectives of the research study which are construction work performance, key performance indicator, method to measure performance and performance measurement methods by EISMS. It reviews the previous works by other researchers published in journals, books and proceedings.

Chapter 3: Construction Monitoring Systems and Features for System Development; This chapter reviews various topics related to the last four objectives of the research study which are current model of computerized construction monitoring system, system development, software architecture and finally network architecture. It reviews the previous work by other researchers published in journals, books and proceedings.

Chapter 4: Research Methodology; For this chapter, the process of the research methodology is presented in chronological order. These are literature review, research survey, EISMS development and EISMS validation and verification.

Chapter 5: Research Survey; This chapter deals with conducting research's survey including design of the questionnaire, method of sampling and data collection, data analysis, results and discussion, and finally survey conclusion

Chapter 6: EISM Development; In this chapter, the process of developing EISM is presented. The process of EISMS development is based on Waterfall Model starting from identification of the system requirement, followed by product design, detail design and coding, unit integration and system implementation/system testing.

Chapter 7: Validation and Verification of the EISMS; An actual case study was carried out to validate and verify the effectiveness of the EISMS. This chapter explains the flow of methodology for validation and verification of EISMS including identifying a suitable project, preparation of basic data 1, and preparation of basic data 2, validation of month 1, verification of EISMS as EIS, verification of EISMS system requirement, validation of month 2-5 and conclusion of validation and verification of EISMS.

Chapter 8: Conclusion and Recommendation; This chapter discussed the conclusion for the whole research, the problems encountered during the research, recommendations for the result and some ideas and suggestions to further extend the development of the EISMS to the next level.

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