VOL. 2, NO. 6, DECEMBER 2007 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

MODELING OF RISK ASSESSMENT FOR INTEGRATED PROJECT MANAGEMENT SYSTEM IN CONSTRUCTION

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ABSTRACT

The experience and successful in the construction industry nowadays depends not only on the traditional civil engineering programs. Project management, over the last 25-30 years, has developed into a methodological and systematic way of dealing with all aspects of construction projects. The wide range of topics that are now representing the domain of construction management is more than emphasis on scheduling, cost control and resource management. They include, but are not limited to, engineering project management concepts, quality management system, environmental management system and techniques for analysis the potential success factors. This paper presents the results of a study carried out to identify some of the core issues in construction management which are mentioned above as a skeleton of integrated project management system for construction industry, and highlights the significance of studying several techniques to explain the strength and weakness for this knowledge area. It is planned that this study will continued to model the integrated project management system and develop an expert system for purpose of education and training to better equip middle and top level managers in the construction industry with the state-of-the-art tools, techniques and methodologies of project management.

Keywords: Project, management, quality, risk, integrated system, construction, industry.

INTRODUCTION

Projects management is critical to the organization success of any field. It is group of activities result in new or changed products, services, environments, processes and organizations. Projects increase sales, reduce costs, improve quality and customer satisfaction, enhance the work environment, and result in many other benefits.

As organizations have recognized the criticality of projects to their success, project management has become a focal point of improvement efforts. More and more organizations have embraced project management as a key strategy for remaining competitive in today's highly competitive business environment. Project management centers, training programs, and organizations change programs to improve project management practices are increasingly common parts of strategic plans to improve organizational effectiveness.

Some organizations are just getting started with project management. Others have reached a level of maturity whereby project management has become a way of life. In the leading organizations, project management is aligned with and integrated into the company's business goals and objectives. No longer, the individual responsibility of the project manager, top management is taking more responsibility for driving the company's project management strategies.

LITERATURE REVIEW

Project management definition

There are more than one definition for project management, "it is the application of collection of tools and techniques to direct the use of divers resources toward the accomplishment of a unique, complex, one-time task within time, cost and quality constraints. Each task requires a particular mix of these tools and techniques structured to fit the task environment and lifecycle of the task" (Oisen, 1971). In the other hand, the British Standard for project management defined project management as "the planning, monitoring and control of all aspects of a project and the motivation of all those involved in it to achieve the project objectives on time and to the specified cost, quality and performance" (BS6079, 1996).

The UK association of project management (APM) also defines the project management in the UK Body of Knowledge (BOK) as "the planning, organization, monitoring and control of all aspect of a project and the motivation of all involved to achieve the project objective safely and within agreed time, cost and performance criteria. The project manager is the single point of responsibility for achieve this" (APM, 1993). Other definitions have been offered, "the project management is a human activity that achieves a clear objective against time scale" (Reiss, 1993). Turner suggests that project management could be described as "the art and science of converting vision into reality" (Turner, 1996).

For more than 40 years, American companies have been using the principles of project management to get work accomplished. Yet, for more than 30 of these years, very few attempts were made to recognize project management as a core competency for the company. There were three reasons for this resistance to project management. First, project management was viewed as simply a scheduling tool for the workers. Second, since this scheduling tool was thought to belong at the worker level, executives saw no reason to look more closely at project management, and thus failed to recognize the true benefits it could bring. Third, executives were fearful that project management, if viewed as a core competency, would require them to decentralize authority, to delegate decision-making to the project managers, and thus to diminish the executives' power and authority base (Harold, 2001).

Principles of traditional project management

The thinking within the principles of management usually associated with the management of people. The management of people includes defining what the business unit will do, planning for the number and type of staff who will do it, organizing the staff, monitoring their performance of the tasks assigned them, and finally bringing a close to their efforts. Those same principles also apply to projects. Robert and Rudd define the Project Management as a method and a set of techniques based on the accepted principles of management used for planning, estimating, and controlling work activities to reach a desired end result on time-within budget and according to specification. Figure-1 shows these process phases of a project (Robert and Rudd, 2003).

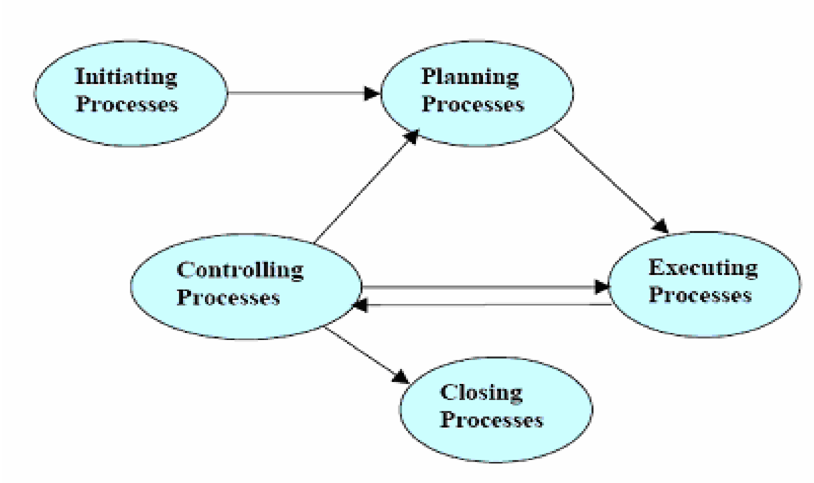

Figure-1. Process phases of a project (Robert and Rudd, 2003).

New concepts in project management

New conceptual direction in project management was developed during 1990s. Project management began to mature in virtually all types of organizations, including those firms that were project-driven, those that were non-project-driven, and hybrids. Knowledge concerning the benefits project management offered now permeated all levels of management. Firman mentioned, "There is a need to fundamentally change the project management philosophy of the industry. Rather than each party maintaining a project management system, there needs to be a single, integrated project-based system" (Firman, 2002). Figure-2 shows the main knowledge areas that be considered by project manager. Thee areas include identification process such as scope management, implementation processes as time, cost, quality, resources and communication management. Beside these areas there are other processes as project management, risk management and integration management can be considered as leadership processes.

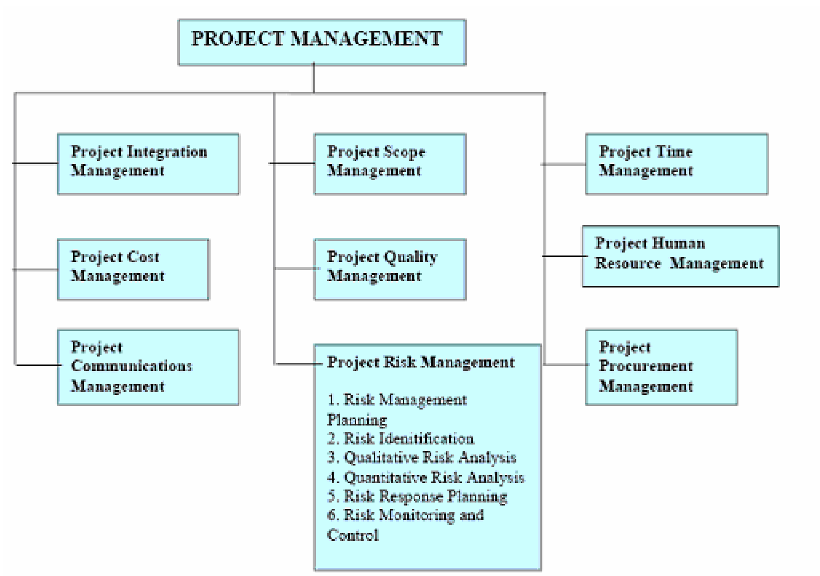

Figure-2. Project management knowledge areas.

METHODOLOGY

The focus of this survey was experienced project managers, site engineers and quality control engineers in the Middle East construction industry. The questionnaire list developed depending on the requirements of ISO 9000:2000 and ISO 1006:2003. First form distributed on sample of 20 questionnaires to determine and measure the reasonability of questions and if they are easy to answered by questionnaires. Then a total of 80 of final and developed questionnaire lists were distributed, of which 46 were completed and returned. This gives a response rate of 57.5%, which is quite good considering the very busy schedule that most project managers and engineers have to follow in Middle East region. The average number of years that the questionnaires had held their position was more than 7 years. The questionnaire was divided into two sections. The first asked about the effect of the risk around each element QMS and PMS on the project cost, the second was for assessment the occurrence of risks probability for each element. For risk effect around the element, the questionnaire was designed to gauge the degree of risk effect on project cost. The respondents were asked to indicate their response by noting any number from 1-10, with 1 being least effect and 5 very effect. For probability of occurrence, the participants were asked to respond by noting a number from 1-10, with 1 low probability and 5 high probability. Table-1 shows the quality requirements and project management functions used for purpose of this study.

Table-1. Quality requirement and project management functions.

SYSTEM ELEMENTS			
1	Quality system	9	Time related process
2	Management responsibility	10	Cost related process
3	Resources management	11	Resources related process
4	Product realization	12	Personnel related process
5	Measurement, analysis and development	13	Communication related process
6	Strategic process	14	Risk related process
7	Independency management process	15	Purchasing related process
8	Scope related		

The weight for each element and specific weight obtained as below (Ibrahim, 2006):

Weight of element = effect x probability ……………….. (1)

Specific weight of an element = weight of the element / total weight of all elements …... (2)

Dispersion of data collected was studied in order to understand measure; first, the type of data distribution relative to central tendency. If data are widely dispersed, the central location is less representative of data as a whole than it would be for data more closely centered around the mean. Secondly, to determine the extreme values that should be excluded from data set and to recalculate the mean for data set. Third, to compare dispersions of various samples, wide spread of value away from the center is undesirable or presents an unacceptable risk, it is needed to recognize and avoid distributions with the greatest dispersion (Levin, 1981). According to Levin, the four equation for range of data, standard deviation, standard score, and coefficient of variation are explained below.

At first the range was measured for understanding the dispersion of data as in equation (3):

Range = value of highest observation – value of lowest observation ……………………………………...... (3)

Then we calculate the standard deviation to understand the type of dispersion and how the data is far from its mean as in equation (4):

$$\text{Standard deviation } (\sigma) = \sqrt{\frac{\sum f(x-\mu)^2}{N}} \quad \ldots\ldots\ldots\ldots(4)$$

(f) = frequency of observation, x = observation, μ = mean of observation, N= number of observation

Standard score also studied to explain exactly how much each value in data set far from mean in term of units of standard deviation that lie above or below the mean as in equation (5):

$$\text{Standard score} = \frac{(x-\mu)}{\sigma} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The results of standard score used for each reading used to exclude data that so far from mean by more than 2σ (two standard deviation) which called extreme values, so the final data sample represent about 95% of data that are the most nearest values to the mean as shown in Figure-3. Same thing was done for all data collected through questionnaire.

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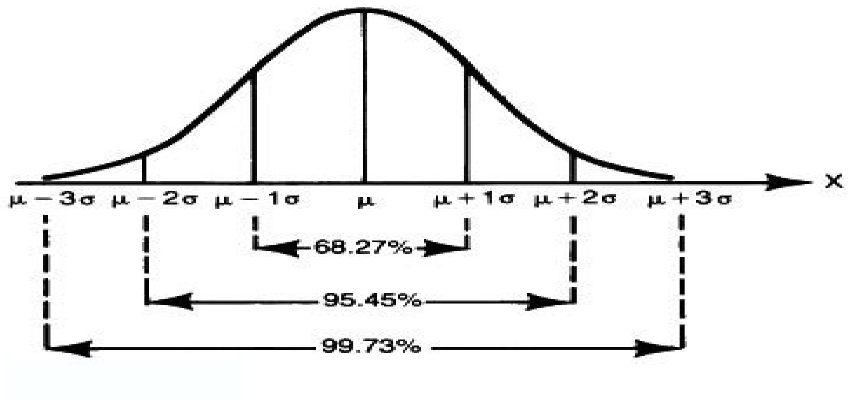

Figure-3. Normal distribution curve.

Nevertheless, standard deviation still absolute measure of dispersion that expresses variation in the same units as the original data. So for compare two set of data or more we can not use only the standard deviation and mean , we need a relative measure that give indication for the magnitude deviation relative to the mean of data set. The coefficient of variation is one such relative measure of dispersion. It relates the standard deviation as a percentage of the mean as in equation (6):

$$\text{Coefficient of variation} = \frac{\sigma}{\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

RESULTS AND DISCUSIONS

The characteristics of the data collected for effect of risks around the project management processes on the project cost are explained in Table-2. Mean, standard deviation and coefficient of variation was obtained for each element. The risk around time related process was the most factor that effect on the project cost up to 39.5% of project cost, followed by cost related process by 33% then strategic process by 20.17%, respectively.

The most elements that the questioners hesitated around there effect value were independency management process. The coefficient of variation was 40.4% of the element mean value, followed by personnel related process with 22.99%, then scope related process with 19.2%, respectively.

Table-2. Project management processes, effects on project cost and probability of occurrence.

Project management processes	Effect on project cost			Probability of occurrence		
	Mean (μ) %	Stand. Dev. (σ)	Coeff. of variation	Mean (μ) %	Stand. Dev. (σ)	Coeff. of variation
Strategic process	20.166667	3.0605011	0.15176	10.4167	1.02062	0.09798
Independency management	7	2.8284271	0.40406	12	0.63246	0.05271
Scope related	9.6666667	1.8618987	0.19261	3.5	0.83666	0.23905
Time related	39.5	6.7453688	0.17077	26	1.26491	0.04865
Cost related	33	5.2153619	0.15804	30.6667	2.33809	0.07624
Resources related	14.166667	1.4719601	0.10390	13.8333	2.13698	0.15448
Personnel related	15.166667	3.4880749	0.22998	6.08333	0.66458	0.10925
Communication related	10.5	1.8708287	0.17817	11.75	0.88034	0.07492
Risk related	12.5	1.8708287	0.14966	10.5	1.04881	0.09989
Purchasing related	9.5	1.0488089	0.11040	13.1667	1.94079	0.14740

While the probabilities of risks occurrence collected for project management processes show that the cost related process risk is the most probable to occurred by rate 30.7% followed by time related process risks by rate of 26% then resources related process risks with rate of 13.8%.

The most elements that the questioners hesitated around there effect value were scope related process, its coefficient of variation was 23.9% of the element mean value, followed by resources related process with 15.4%, then purchasing related process with 14.7% respectively. On other hand, the element of risks that most of questioners are agreed with minor deviation are time related process with rate of 4.8%, followed by independency management process with 5.2% then communication related process with rate of 7.49%.

The characteristics of the data collected for effect of risks around the quality management processes on the project cost are explained in Table-3. Mean, standard deviation and coefficient of variation was obtained for each element. The risk around product realization process was the most factors that effect on the project cost up to 27.7% of project cost, followed by process of measurement, analysis and development by 19.5% then management responsibility process by 20.17%, respectively.

The most elements that the questioners hesitated around there effect value were product realization process. The coefficient of variation was 13.4% of the element mean value, followed by management responsibility process with 11.9%, then quality system process with 11.78% respectively.

Table-3. Quality management processes, effect on project cost and Probability of occurrence.

Quality management processes	Effect on project cost			Probability of occurrence		
	Mean (μ) %	Stand. Dev. (σ)	Coeff. of variation	Mean (μ) %	Stand. Dev. (σ)	Coeff. of variation
Quality system	12	1.414214	0.117851	6	1.414214	0.235702
Management responsibility	17.3333	2.065591	0.119169	14.83333	1.32916	0.089606
Resources management	10.8333	1.169045	0.107912	20	1.414214	0.070711
Product realization	27.6667	3.723797	0.134595	32.16667	2.71416	0.084378
Measurement, analysis and development	19.5	1.870829	0.09594	11.33333	1.505545	0.132842

While The probabilities of risks occurrence collected for quality management processes show that the product realization risks is the most probable to occurred by rate 32.17% followed by resources management process risks by rate of 20% then management responsibility process risks with rate of 14.8%.

The most elements risks that the questioners hesitated around there probable value were quality system risks, its coefficient of variation was 23.57% of the element mean value, followed by measurement, analysis and development risks with 13.28%, then management responsibility process risks with 8.96%. On other hand, the elements of risks that most of questioners are agreed with minor deviation are resources management process with rate of 7.0%, followed by product realization risks with 8.4%.

For each source of risk related to processes within integrated quality management system, the weight simply calculated by multiplying the effect of each process risks by the probability of it. Table-4 lists the fifteen sources of risks with their effect assessment and probability of occurrence (column 1 and 2, respectively). The gross weight obtained for each element in column 3 then by divided each weight by the sum of all gross weight for all element (sum of column 3), the specific weight would be determined as percent.

Table-4. Integrated management system, specific weight of elements.

SYSTEM ELEMENTS		Column 1 Effect on project cost %	Column 2 Probability of occurrence %	Column 3 Gross weight Col. 1 x Col. 2	Column 4 Specific weight %
1	Quality system	12	6	72	1.534668
2	Management responsibility	17.33333	14.83333	257.111	5.480278
3	Resources management	10.83333	20	216.6666	4.618212
4	Product realization	27.66667	32.16667	889.9446	18.96902
5	Measurement, analysis and development	19.5	11.33333	220.9999	4.710576
6	Strategic process	20.16666667	10.41666667	210.0694	4.477595
7	Independency management	7	12	84	1.790446
8	Scope related	9.666666667	3.5	33.83333	0.721152
9	Time related	39.5	26	1027	21.89033
10	Cost related	33	30.66666667	1012	21.57061
11	Resources related	14.16666667	13.83333333	195.9722	4.177115
12	Personnel related	15.16666667	6.083333333	92.26389	1.966589
13	Comm. related	10.5	11.75	123.375	2.629717
14	Risk related	12.5	10.5	131.25	2.797572
15	Purchasing related	9.5	13.16666667	125.0833	2.66613
Total:				**4691.569**	**100%**

The results show that the time related process is the most important in the project with specific weight 21.98% followed by the cost related process which of specific weight of 21.57% then product realization with specific weight of 18.96%. This means that the risk around the three elements represents more than 62% of total project risks. The detail comparison for element as listed in Table-3 respectively is shown in Figure-2.

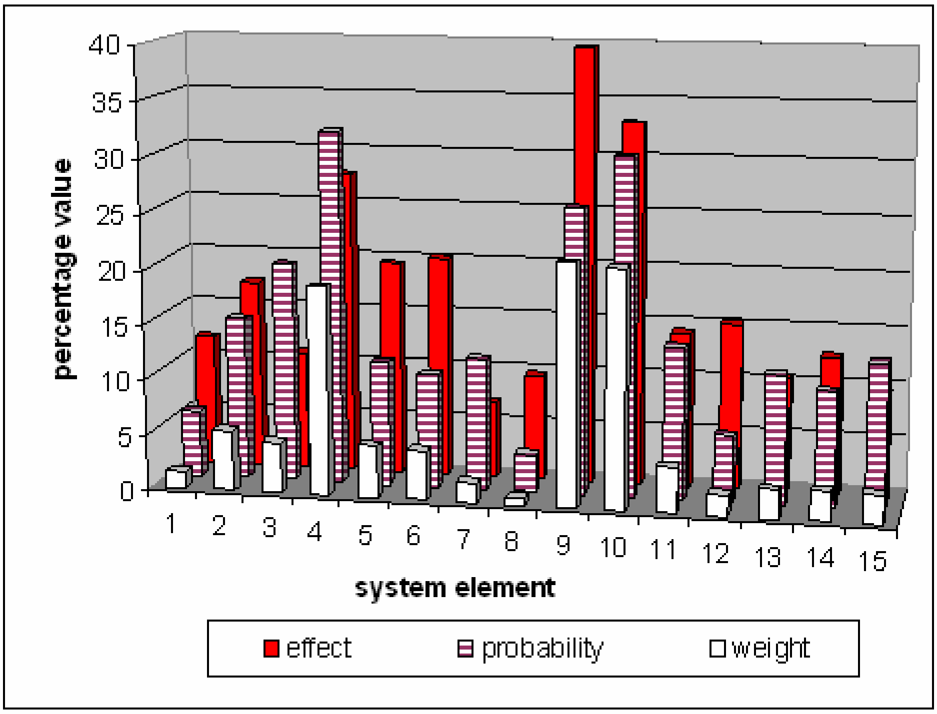

Figure-2. Effect, probability and specific weight for each element.

CONCLUSIONS

- The results of this study confirm that project and quality management processes are an important aspect of the civil engineering and construction industry. Further, it has statistically demonstrated that the project management functions-time related process, cost related process and product realization are the most important articles in the integrated management system.
- The current quality guides have not concentrate on the expected risks around the requirements. It mentioned only the benefits and don't provide the solution for prevent, minimize or release the risk effects.
- Rapid changes in construction technology are contributing to a major complication in process management of the traditional construction projects. This construction change supported by the information technology (IT) need to change the engineering professions toward develops the management skill and support it with same tools of IT.
- This study explain the relative importance for each element within integrated management system as first step, this will follow by develop the research vertically by study the risk factors in detail and horizontally by adding the environmental requirements to the system. For using IT tools, expert system will developed in next step for achieve the analysis of data collected for the project and to provide promote detail prediction reports for the situation of project.

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