An investigation of a risk management decision support system for Iraqi construction projects

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تحقيق نظام دعم قرار ادارة المخاطر في المشاريع الانشائية العراقية

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المستخلص

أدارة المخاطر(RM) تعتبر من اهم عوامل نجاح المشاريع الانشائية وعادة هذه المشاريع لا تملك المعلومات الكافية التي تسهل اجراءات ادارة المخاطر وقرارتها والتي تؤدي الى تقليل المخاطر. مشكلة البحث يمكن تحديدها من خلال مخاطر الادارة وتطبيقها في المشاريع الانشائية وكذلك تحديد نوع الخطر وتعريفه ومتابعته والسيطرة عليه. ولتسهيل فعاليات ادارة المخاطر والقرارات الداعمة لها والتي تساهم في تصنيف الخطر وتحليله واستراتيجية الاستجابة وتطوير الموديل الخاص بها. ادوات دعم القرار ضرورية لتعريف الخطر والسناريو والفعالية ونظام تكامل فعاليات الادارة وعلاقته مع فعاليات الادارة مثل التخطيط والكلفة ومتابعة نجاح المشروع. نظام ادارة المخاطر والذي يسمى نظام ادارة المخاطر التكاملي يصمم لدعم المستخدم في كل مراحل المشروع. اهم دوال IRMS احتوائه على تحليلات مونتكارلو MC (الاحتمالية والمعدل) وتشمل فقراته تقييم الخطر والاستجابة تم تطبيق نظام ادارة المخاطر على ثلاث مشاريع انشائية بالعراق من خلال استخدام جميع المعلومات المتوفرة ووجد انخفاض معدل الخطر من عالي الخطر الى متوسط الخطر وللمشاريع الثلاثة.

Abstract

Risk management (RM) is one of the critical success factors for the construction of projects, project participants generally do not have sufficient knowledge pertinent to risk management concept and the number of risk management support tools which facilitate the process are rather low. Research problem can be identify by the process of risk management, applying risk management in construction projects, types and identified, assessing and controlling of risk in construction projects. In order to facilitate risk management activities, decision support tools that will enable risk identification, analysis and response strategy formulation should be developed. Decision support tools are necessary for systematic identification of risks, scenario generation, proactive management of risk and integration of risk management activities with other project management functions such as planning, cost estimating and monitoring project success. The proposed decision support system, namely Integrated Risk Management System (IRMS), is designed to support the user at all phases of the risk management process. Major functions of IRMS include, risk analysis by Monte Carlo (MC) simulation (probability and rating degree), risk assessment by risk rating, risk re-assessment, response generation. The applicability of the system has been tested by a real case study (three Iraqi construction cases) and its functionality has been demonstrated using the data associated with these cases

study (three cases). Risk carting (RC) processes are reduced from high risk management to moderate ones for the three project cases.

Key words: risk management, construction, decision, work package, project information card.

Introduction

In construction projects, risks play a significant part in decision making and may affect the performance of a project. If they are not dealt with sensibly, they may cause cost overruns, delays on schedule and even poor quality. Each project has a different level and combination of risks and sites will adopt different strategies to minimize them because the characteristics of projects are unique and dynamic.

However, while realizing the project in the international area, the construction companies should give necessary importance to risk management concept which simply covers risk identification, analysis and response development stages. The reason to take risk management concept into the consideration is that construction industry is subject to more risk and uncertainty than many other industries due to requirement of multitude of people with different skills and interests, the co-ordination of a wide range of interrelated activities and vulnerability of construction projects to political, economic, social and environmental conditions. Most researchers agreed that risk plays a crucial role in business decision making. The management of risk in projects is currently one of the main topics of interest for researchers and practitioners. Risk management has been designated as one of the eight main areas of the Project Body of Knowledge (PMBoK) by the Project Management Institute (1,2), which is the largest professional organization in the project management field. Starting from early 1970's, lots of studies have been conducted pertinent to risk modeling concept. Some of the researches were related with definition of a systematic risk management process and methodologies in order to eliminate lack of formality. On the other hand, most of the studies have been focused on quantitative risk analysis for time and cost estimation. In recent years, it is noticed by researchers and experts that RM does not mean only risk measurement or quantification processes. On the contrary, as the construction projects have been becoming increasingly complex and dynamic, the significance of soft system approaches which consider human based issues such as experience, knowledge, team work has also considered. This situation leads to the definition of new concepts in RM field such as risk information modeling, risk register data base systems and RM decision support systems which are designed to assist the expert during the decision making process.

In this paper, it is aimed to develop a fully integrated RM decision support system for three real Iraqi construction cases construction projects

Methodology

The purpose of the study on which this paper is based to use Decision Support Tools (DST) for systematic identification of risks, scenario generation, and proactive management of risk and integration of risk management activities with other project

management functions such as planning, cost estimating and monitoring project success. Assess and investigate the application of (DST) for identification of risks, and how this rolls out in practice within the Iraqi construction context, particularly in design and build projects. The research will adopt a mix of different types of Iraqi construction projects. For different types of construction projects are used as cases study to test the performance and impact of implementing of IRM and Monti Carlo (MC).

The aim of this work focus on validating findings from the cases study and as a platform for a 'Knowledge Bridge' between the pre-response and post-response of risk carting processes. Some basic quantitative methods will be applied in reviewing survey data obtained from the application of the DST framework and for setting criteria for the case study selection. In this research, the literature review will be used to explore the principles, application, criteria and theories of DST that address issues related to investigate risk in construction project and coordination of processes and stakeholders in reduce these risks on build projects.

Research problem

Research problem can be identifying by questions have been formulated as:

1. What is the process of risk management?
2. How to apply risk management in construction projects?
3. What risks are there in construction projects?
4. How risks can be identified during construction period?
5. How risks can be assessed during construction period?
6. How risks can be controlled during construction period?

The importance of the research

As the most common and typical project types, construction projects have several characteristics such as specific objects, time limit, financial constraints and economic requirements, special organizational and legal conditions, complexity and systematic characteristics. For that each investment project itself is a complex system. Especially for the construction projects, there are many risk facets and complicated relations, which will influence it. The complicated relations include direct, indirect, obvious, implicit or unpredictable, What's more, the various risk factors will cause different severity of the consequences. If you do not consider these risk factors, or ignore the major factors, they all will cause damage because of decision-making errors. Quality targets, time targets, cost targets are the three objectives of project management. Especially in the construction project, the time objective is closely and inseparably related to the cost objective. Therefore, risk management of construction period is a key part in the risk management of construction.

Research objectives

The overall aim of this study is to let everyone know what risk management is, realize the procedure of risk management in construction project and have a deeper study on the application of risk management during construction period, therefore, a better

project output and better value for both clients and constructors. There are two objectives of this study:

1.To assess the most major and common risks which cause bad effect on construction period.

2.To figure out reasonable solutions of construction project risk by using decision support system tools.

The research sample

The example project is a real project which has just started in Iraq. The city of the project is Baghdad which is one of the biggest cities in Iraq. The projects are three projects; rebuilding, high-ways, building (Three Iraqi construction project A,B, and C; these projects data are secrets of companies and the Ministry of Housing and Construction). All information regarding the details of the project like schedule, budget, payment type etc are registered by using the project information card.

Procedural definitions of terms

Decision Support Tools (DST) is a systematic identification of risks, scenario generation, and proactive management of risk and integration of risk management activities with other project management functions such as planning, cost estimating and monitoring project success.

Hierarchical Risk Breakdown Structure (HRBS) is to describe action breakdown structure" for construction projects. Integrated Risk Management System (IRMS), is designed to support the user at all phases of the risk management process and to integrate risk management activities with other project management functions in the bid preparation stage of construction projects. Monte Carlo (MC) is a software program identify; simulation (probability and rating degree), risk assessment by risk rating, risk re-assessment, response generation. Project Management Institute (PMI) is the largest professional organization with over 100,000 professional members representing 125 countries, is dedicated to project management field.

Project Management Body of Knowledge (PMBoK): PMI proposed a risk management methodology to eliminate informality of risk management application by the sector participants which is called asPMBoK. Risk carding (RC) is a process covers assignment of the risk sources from Hierarchical Risk Breakdown Structure (HRBS) to pre-defined work packages by using a uniform language coding system. Risk management (RM) is one of the critical success factors for the construction of projects. It is a discipline for living with the possibility that future events may cause adverse effects.

Theoretical frame work

Definition of Risk, Uncertainty and Risk Management

Decision-making takes place in an environment which has three components as certainty, uncertainty and risk (1). Certainty can be defined as a situation in which all the factors can be exactly specified and known by the decision-maker which does not

happen very often in the construction industry. In other words, uncertainty arises as decision-making is oriented towards the future. According to Raftery (2), the word "uncertainty" is used where it is impossible to describe a situation in terms of probability of occurrence of an event. On the other hand, risk can be stated as a situation where the actual outcome an activity deviates from the estimate or forecast value (2). A broad definition of risk is the probability that an adverse event occurs during a stated period of time (3). This definition considers negative side of risk only. Similar to this definition, Moavenzadeh and Rossow (4) regarded risk as an exposure to loss only. On the other hand, Porter (5), and Perry and Hayes (6) have expressed risk as an exposure to economic loss or gain. Furthermore, Chapman (7) defined risk as "exposure to possibility of economic and financial loss or gain, physical damage or injury, or delay as a consequence of the uncertainty associated with pursuing a particular course of action". According to Flanagan and Norman (1), risk management (RM) is a discipline for living with the possibility that future events may cause adverse effects. Although this definition correlates the term risk with chance of bad consequences or effects, it can also refer to possibility of opportunities. Chapman and Ward (8) stated the aim of RM as removing or reducing the possibility of underperformance. They declared that fundamental or essential purpose of RM is to improve project performance by systematic identification, appraisal and management of project related risks. Another explicit definition of RM is done by Dikmen et al. (9) who define risk management as definition of objective functions to represent the expected outcomes of a project, measuring the probability of achieving objectives by generating different risk occurrence scenarios to ensure meeting/exceeding the preset objectives. Actually, the six W's approach that is shown in Fig.1 constitutes the basis for "contingency plans" which are second level plans related with how to respond to threats or opportunities associated with a "base plan" or a target scenario which indicates how well the project will go. Risk management is usually related with the evaluation and development of contingency plans supporting base plans (8); however, application of effective risk management should start in the development of project base plans.

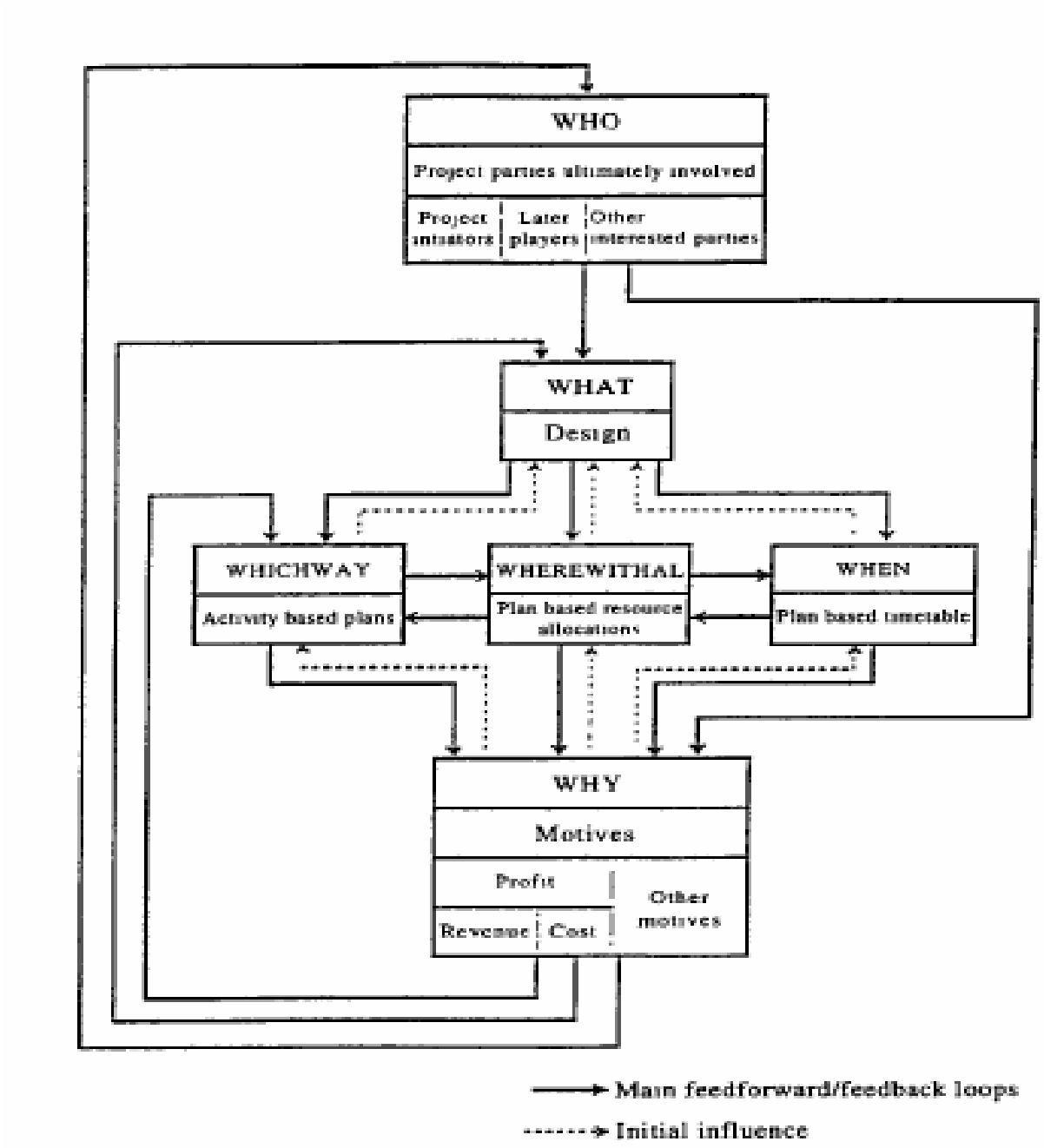

Figure (1): The six W's of PRAM methodology (8).

Project Management Body of Knowledge (PMBoK)

Project Management Institute (PMI), which is the largest professional organization with over 100,000 professional members representing 125 countries, is dedicated to project management field. PMI proposed a risk management methodology to eliminate informality of risk management application by the sector participants which is called as Project Management Body of Knowledge (PMBoK). According to PMBoK, risk management forms one of the so called nine functions of project management. Modifications' regarding risk management methodology is still being carried out and the revised version of PMBoK is published in 2000 which includes minor revisions regarding project risk management. According to PMBoK (10),

project risk management includes the processes concerned with identifying, analyzing and responding to project risk. Fig. 2 summarizes risk management methodology of PMBoK.

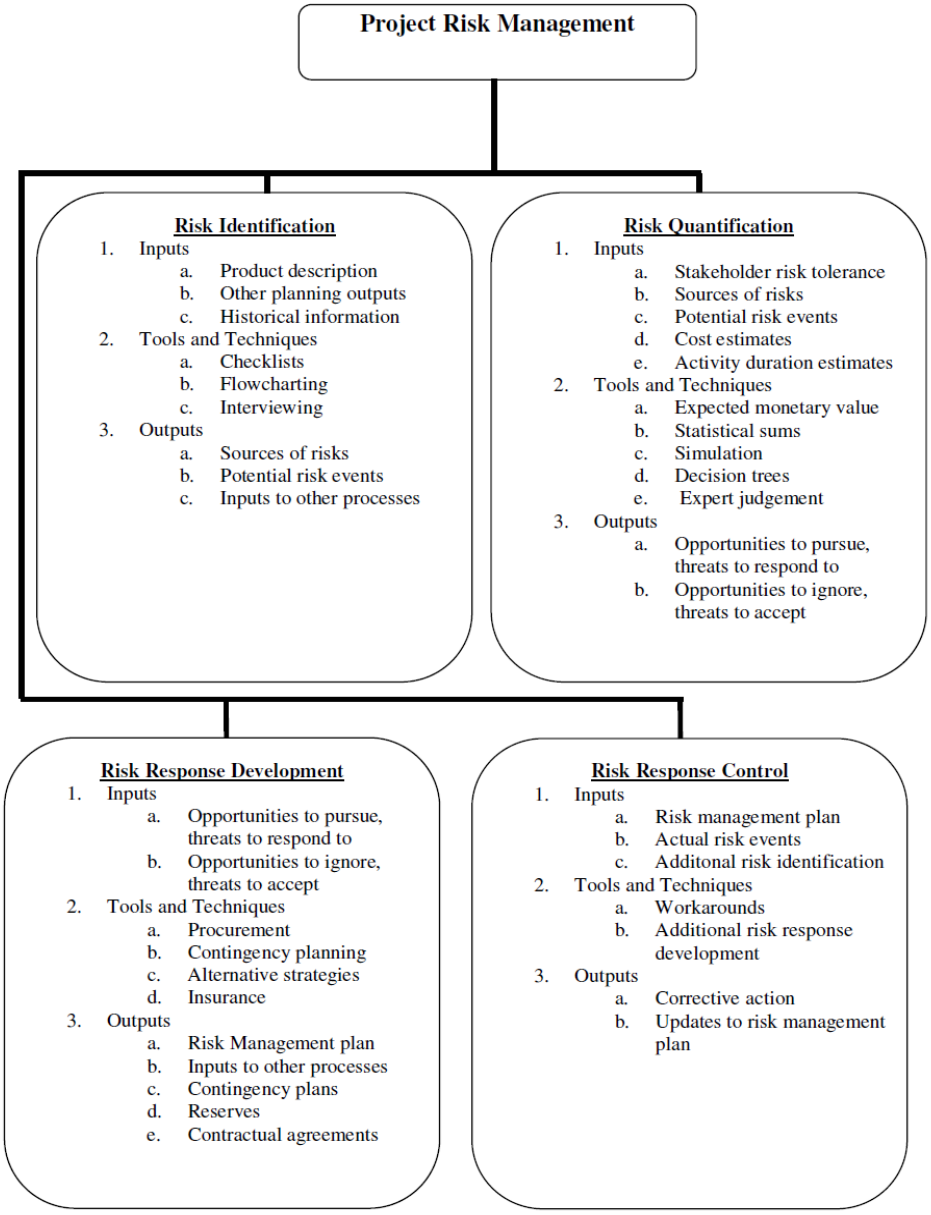

Figure (2): Project Risk Management Overview of PMBoK (10)

Results and discussion

Monte Carlo simulation

Monte Carlo simulation is a computerized mathematical technique that allows people to account for risk in quantitative analysis and decision making. The technique is used by professionals in such widely disparate fields as finance, project management,

energy, manufacturing, engineering, research and development, insurance, oil & gas, transportation, and the environment (9). Monte Carlo simulation furnishes the decision-maker with a range of possible outcomes and the probabilities they will occur for any choice of action. It shows the extreme possibilities—the outcomes of going for broke and for the most conservative decision—along with all possible consequences for middle-of-the-road decisions.

Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values—a probability distribution—for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete. Monte Carlo simulation produces distributions of possible outcome values. By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis. Common probability distributions include:

Normal – Or "bell curve." The user simply defines the mean or expected value and a standard deviation to describe the variation about the mean. Values in the middle near the mean are most likely to occur. It is symmetric and describes many natural phenomena such as people's heights. Examples of variables described by normal distributions include inflation rates and energy prices.

Lognormal – Values are positively skewed, not symmetric like a normal distribution. It is used to represent values that don't go below zero but have unlimited positive potential. Examples of variables described by lognormal distributions include real estate property values, stock prices, and oil reserves.

Uniform – All values have an equal chance of occurring, and the user simply defines the minimum and maximum. Examples of variables that could be uniformly distributed include manufacturing costs or future sales revenues for a new product.

Triangular – The user defines the minimum, most likely, and maximum values. Values around the most likely are more likely to occur. Variables that could be described by a triangular distribution include past sales history per unit of time and inventory levels.

PERT- The user defines the minimum, most likely, and maximum values, just like the triangular distribution. Values around the most likely are more likely to occur. However values between the most likely and extremes are more likely to occur than the triangular; that is, the extremes are not as emphasized. An example of the use of a

PERT distribution is to describe the duration of a task in a project management model.

Discrete – The user defines specific values that may occur and the likelihood of each. An example might be the results of a lawsuit: 20% chance of positive verdict, 30% change of negative verdict, 40% chance of settlement, and 10% chance of mistrial.

During a Monte Carlo simulation, values are sampled (questioners data of the three selected Iraqi construction projects) at random from the input probability distributions. Each set of samples is called iteration, and the resulting outcome from that sample is recorded. Monte Carlo simulation does this hundreds or thousands of times, and the result is a probability distribution of possible outcomes. In this way, Monte Carlo simulation provides a much more comprehensive view of what may happen. It tells you not only what could happen, but how likely it is to happen.

Monte Carlo simulation provides a number of advantages over deterministic, or "single-point estimate" analysis:

- Probabilistic Results. Results show not only what could happen, but how likely each outcome is.
- Graphical Results. Because of the data a Monte Carlo simulation generates, it's easy to create graphs of different outcomes and their chances of occurrence. This is important for communicating findings to other stakeholders.
- Sensitivity Analysis. With just a few cases, deterministic analysis makes it difficult to see which variables impact the outcome the most. In Monte Carlo simulation, it's easy to see which inputs had the biggest effect on bottom-line results.
- Scenario Analysis: In deterministic models, it's very difficult to model different combinations of values for different inputs to see the effects of truly different scenarios. Using Monte Carlo simulation, analysts can see exactly which inputs had which values together when certain outcomes occurred. This is invaluable for pursuing further analysis.
- Correlation of Inputs. In Monte Carlo simulation, it's possible to model interdependent relationships between input variables. It's important for accuracy to represent how, in reality, when some factors go up, others go up or down accordingly.

Demonstration of an IRMS application on a real case

IRMS model gives more attention to risk identification, classification and rating phases which constitute the fundamentals of the risk analysis and response development activities. For this reason, a special process as risk carting (RC) process is provided by IRMS to formalize and systematize the identification and rating phases. RC process covers assignment of the risk sources from Hierarchical Risk

Breakdown Structure (HRBS) to pre-defined work packages by using a uniform language coding system. In addition, the system finalize risk analysis which is started from risk classification and rating phase, by executing MC simulation and enables calculation of final project cost based on the defined risk sources. To monitor and update the status of the risk sources and work packages, some tabular and graphical reports are provided by the IRMS report engine to carry out re-evaluation task by the experts.

To illustrate how the model works and to demonstrate the applicability and accuracy of the IRMS RM model and corresponding system, a real case project is evaluated and each phase of the IRMS RM process is executed by an expert. Almost all of the features of the model are illustrated by a real case example, details of which are given below.

IRMS RM session starts with the registration of projects information which will be recorded in corporate memory. The example project is a real project which has just started in Iraq. The city of the project is Baghdad which is one of the biggest cities in Iraq. The projects are three; buildings, rebuilding, high-ways. All information regarding the details of the project like schedule, budget, payment type etc are registered by using the project information card. The projects information cards are shown in Tables 1 to 3.

Table (1): Project information card of the Iraqi project A (rebuilding)

Project Information Card					
1	Project Name	Project A			
2	Project Description	Rebuilding			
3	Project Type	Infrastructure			
4	Project Location	Country		Iraq	
		Region/City		BAGHDAD	
5	Project Duration	Month		Ms1= 10, Ms2= 16 , Ms3=19, Ms4=33	
6	Project Timeframe	Start Date		21/ 02 /2005	
		End Date		20/ 02 /2008	
7	Project Delivery System (Contr.Type)	Db		Epc	
		Dbb	√	Pot	
8	Party Arrangement	Single Company	√	Consortium	
		Joint Venture		Other	
9	Payment Type	Unit Price		Cost + Fee	$10*10^9$ Id
		Lump Sum	√		
10	Currency	Euro		Local Currency	√
		$			
11	Project Budget	$10*10^9$ Id			
12	Date Of Evaluation	23/ 06 /2009			
13	Risk Administrator	Aea			

Table (2): Project information card of the Iraqi project B(high way)

Project Information Card					
1	Project Name	Project B			
2	Project Description	High Way			
3	Project Type	Infrastructure			
4	Project Location	Country		Iraq	
		Region/City		Baghdad	
5	Project Duration	Month		Ms1= 10, Ms2= 16 , Ms3=19, Ms4=33	
6	Project Timeframe	Start Date		12/ 12 /2004	
		End Date		11/ 12 /2006	
7	Project Delivery System (Contr.Type)	Db		Epc	
		Dbb	√	Pot	
8	Party Arrangement	Single Company	√	Consortium	
		Joint Venture		Other	
9	Payment Type	Unit Price		Cost + Fee	
		Lump Sum	√		
10	Currency	Euro		Local Currency	√
		$			
11	Project Budget	$13*10^9$			
12	Date Of Evaluation	25/ 10 /2007			
13	Risk Administrator	Aea			

Table (3): Project information card of the Iraqi project C (infrastructure)

Project Information Card					
1	Project Name	Project C			
2	Project Description	Building			
3	Project Type	Infrastructure			
4	Project Location	Country		Iraq	
		Region/City		Baghdad	
5	Project Duration	Month		Ms1= 10, Ms2= 16 , Ms3=19, Ms4=33	
6	Project Timeframe	Start Date		22/05 /2006	
		End Date		21/05 /2008	
7	Project Delivery System (Contr.Type)	Db		Epc	
		Dbb	√	Pot	
8	Party Arrangement	Single Company	√	Consortium	
		Joint Venture		Other	
9	Payment Type	Unit Price		Cost + Fee	
		Lump Sum	√		
10	Currency	Euro		Local Currency	√
		$			
11	Project Budget	$2*10^9$id			
12	Date Of Evaluation	20/04 /2008			
13	Risk Administrator	Aea			

If the project information card of the example project A (Table 1) is examined, it is noticed that the project consists of four milestones with 10, 16, 19 and 33 months respectively. Furthermore, tender documents indicate that the progress payments will be certified based on the defined four milestones instead of monthly progress payments. Although the contract allows 15% advance payments, the schedule should be taken into consideration as a risk source if the duration of the milestones is considered. According to tender documents, the type of the project delivery system is "design bid- build". In this type of contract, the contractor is responsible for the construction of civil works and electro-mechanical installation works only. All of the design tasks are carried out by design companies under the control of the client. With

this kind of a project delivery system, the ownership of design risk source belongs to the designer or client.

In this work, the contractor is not a member of consortium or does not have any partner. The estimated budget of the project is around $10*10^9$ ID for construction of sub/super structure construction works and electro-mechanical installations. After project information is registered, the project is divided into work packages. The number of work packages depends on the kind and complexity of the project and analysis detail request of the risk administrator. In this project, first level breakdown is found sufficient for the risk analysis by the expert. The work packages and corresponding estimated budgets are listed in Table 4. RC process starts after definition of work packages. Before starting RC process, risk administrator decides on the number of risk experts who will join the RC process and rate the defined risk sources. In this project, single decision maker option is selected and thus risk administrator is the only expert to rate the assigned risk sources. As stated before, IRMS provides a template HRBS to facilitate risk identification phase. Actually, the template HRBS is constituted to cover whole project documents including contracts, project participant profiles, project country conditions and technical issues. For this reason, categorized risk sources can easily be assigned to the work packages

Table (4): 1st level WBS and estimated budget values of the project A

Work Package #	Work Package Name	Estimated Budget * 10^9
WP1	SUB/SUPER STRUCTURE CONSTRUCTION	5
WP2	UTILITY SYSTEM INSTALLATION	1
WP3	ROAD/LANDSCAPE SYSTEMS INSTALLATION	0.3
WP4	POWER SYSTEM INSTALLATION	3
WP5	TRACK SYSTEM INSTALLATION	0.2
WP6	OPERATING SYSTEM INSTALLATION	0.1

The major issues pertinent to risk identification process for the defined work packages are explained below:

- If the tender documents are examined, it can be noticed that there is inconsistency between the durations of the milestones.
- For some of the work packages like operating system installation strict quality requirement is noticed.

- Similarly, for power system and track system installation the health and safety issues will be an important risk source.
- For this kind of projects, the scope changes may always be a risk source element.
- It is identified that most of the employees of this company is from Iraq. Therefore, this situation may lead to some risk sources regarding consultant category.
- One major risk source is labor risk category. In tender documents, it is declared that the nationality of the laborers have to be Polish.
- Finally, the company should carry out an internal scanning to identify risk sources regarding project management concept.

The details of RC process for project A are illustrated in Tables 5 to Table 10.

Table (5): Risk carting process sheet of Iraqi project A

WORKPACKAGE 1										
ESTIMATED COST= $5*10^9$										
PRE-RESPONSE							POST-RESPONCE			
NO	RISK CODE	RISK DESCRIPTION	OWNERSHIP	PROBABILITY	IMPACT	RATNG	RESPONSE CODE	PROBABILITY	IMPACT	RATIN
1	R1.S.02	Unrealistic milestones	contractor	3	4	12	R.R1.01	2	3	6
2	R1.S.03	Working hour restriction	client	2	3	6		2	3	6
3	R1.E.01	Strict env. requirements	contractor	3	3	9	R.T.1.02	2	3	6
4	R1.E.02	Vagueness in regulation	contractor	4	3	12	R.R.1.01	3	2	6
5	D1.C.02	Vagueness in construction method	contractor	2	3	6	R.T.1.02	1	3	3
6	P1.C1.01	Negative attitude towards foreign contractors	contractor	4	4	16	R.R.1.01	4	3	12
7	P1.C1.02	Poor performance of client	client	4	2	8		4	3	12
8	P1.C1.04	Vagueness of req / client expectation	client	2	5	10		2	5	10
9	P1.S.02	Vagueness in scope	contractor	2	4	8	R.T.1.01	2	3	6
10	P1.C2.01	Poor performance of consultant	contractor	4	5	20		3	4	12
11	P1.P.03	Poor performance of PM staff	contractor	2	5	10	R.R.1.04	1	1	1
12	P1.P.04	Poor communication between parties	contractor	2	3	6	R.R.1.03	2	2	4
13	P1.P.05	Lack of experience of PM staff	contractor	1	5	5	R.R.1.04	1	1	1
14	R2.M.04	Delay in material delivery	contractor	3	5	15	R.T.1.02	2	3	6
15	R2.M.06	Improper material definition	Client	1	2	2		1	2	2
16	R2.E.01	Unavalibitiy of equipment	contractor	2	4	8	R.T.1.02	2	3	6
17	R2.L.02	Poor productivity of workers	contractor	3	4	12	R.T.1.02	3	1	3
18	R2.L.04	Restrictions on foreign workers	contractor	5	5	25	R.R1.01	4	3	12
19	R2.F.01	Inappropriateness of budget estimate	contractor	2	5	10	RR2	2	4	8
20	P2.E.01	Vagueness of ground conditions	contractor	3	4	12	R.T.1.02	3	2	6
21	P2.S.01	Physical constraints	Contractor	1	4	4	R.T.1.01	1	2	2
22	C1.C.05	Dispute resolution clauses	Contractor	3	5	15	R.T.1.01	3	4	12
23	C1.B.01	Delay in site hand –over	Client	4	1	4		4	1	4
24	C1.B.03	Delay in permits / approval	Client	3	5	15		3	3	9
25	C1.B.04	Delay in progress payments	Client	3	4	12		3	4	20
26	D1.D.03	Delay in design	designer	3	4	12		3	4	12
27	D1.D.04	Complexity	contractor	3	2	6	R.T.1.02	2	2	4
Total value						280				191
PRE.RESP.RATING						10.4				7.1
RISK CATEGORY					SIGNIFICANT				MODERATE	

Table (6): Risk carting process sheet of Iraqi project A

WORKPACKAGE 2										
ESTIMATED COST=1*10^9										
PRE-RESPONSE							POST-RESPONSE			
NO	RISK CODE	RISK DESCRIPTION	OWNERSHIP	PROBABILITY	IMPACT	RATNG	RESPONSE CODE	PROBABILITY	IMPACT	RATING
1	R1.S.03	Working hour restriction	Client	2	3	6		2	3	6
2	R1.Q.02	Defective design	designer	1	5	5		1	5	5
3	R1.E.01	Strict env. Requirements	contractor	3	4	12	R.T.1.02	2	3	12
4	R1.E.02	Vagueness in regulations	contractor	3	4	12	R.R.1.01	3	3	9
5	D1.S.02	Vagueness in construction scope	contractor	3	4	12	R.T.1.01	2	2	4
6	P1.C1.01	Negative attitude towards foreign contractors	contractor	4	4	16	R.R.1.01	4	3	12
7	P1.C1.02	Poor performance of client	Client	3	3	9		3	3	9
8	P1.C1.05	Change in requirements	contractor	2	3	6	R.T.1.01	2	2	4
9	P1.S.02	Poor performance sub-contractor	contractor	3	4	12	R.T.1.02	2	2	4
10	P1.C2.02	Conflicts	contractor	4	5	20	R.T.1.01	3	4	12
11	P1.P.01	Strict documentation requirements	contractor	3	2	6	R.R.1.03	2	1	2
12	P1.P.03	Poor performance of PM staff	contractor	2	4	8	R.R.1.04	1	1	1
13	P1.P.04	Poor communication between parties	contractor	3	3	9	R.R.1.03	2	2	4
14	R2.M.04	Delay in material delivery	contractor	3	5	15	R.T.1.02	2	3	6
15	R2.M.05	Restrictions on imports	contractor	2	2	4	R.T.1.01	1	2	2
16	R2.L.02	Poor productivity of workers	contractor	3	4	12	R.T.1.02	2	3	6
17	R2.L.04	Restrictions on foreign workers	contractor	5	3	15	R.R.1.01	5	2	10
18	R2.F.01	Inappropriateness of budget estimate	contractor	2	4	8	R.R.2	2	4	8
19	C1.C.01	Vagueness of clauses	Contractor	3	4	12	R.T.1.01	3	3	9
20	C1.C.04	Lack of major contract clauses	contractor	4	4	16	R.T.1.01	4	3	12
21	C1.C.05	Dispute resolution clauses	contractor	4	5	20	R.T.1.01	3	4	12
22	C1.B.03	Delay in permits / approval	Client	4	5	20		4	4	16
23	C1.B.04	Delay in progress payments	Client	4	4	16		4	3	12
24	P2.S.01	Physical constraints	contractor	4	4	16	R.T.1.01	4	3	12
Total value						287				189
PRE.RESP.RATING						11.9				7.9
RISK CATEGORY				SIGNIFICANT					MODERATE	

Table (7) : Risk carting process sheet of Iraqi project A

WORKPACKAGE 3										
ESTIMATED COST=0.3*10^9ID										
PRE-RESPONSE							POST-RESPONSE			
NO	RISK CODE	RISK DESCRIPTION	OWNERSHIP	PROBABILITY	IMPACT	RATNG	RESPONSE CODE	PROBABILITY	IMPACT	RATIN
1	D1.C.03	novelty	contractor	2	3	6	R.T.1.02	1	3	2
2	P1.C1.01	Negative attitude towards foreign contractors	contractor	4	4	16	R.R.1.01	4	4	12
3	P1.C1.04	Vagueness of req / client expectation	contractor	3	5	15	R.T.1.01	3	5	9
4	P1.S.01	Unavailability of sub-contractor	contractor	2	4	8	R.R.1.01	2	4	6
5	P1.P.04	Poor communication between parties	Contractor	3	3	9	R.R.1.03	2	3	4
6	P1.P.05	Lack of experience of PM staff	Contractor	1	3	3	R.R.1.04	1	3	1
7	R2.M.04	Delay in material delivery	Contractor	3	3	9	R.T.1.02	3	3	4
8	R2.M.05	Restrictions on imports	Contractor	3	3	9	R.T.1.01	3	3	6
9	R2.M.06	Improper material definition	Client	2	4	8		2	4	8
10	R2.L.04	Restrictions on foreign workers	Contractor	5	2	10	R.R.1.01	5	2	5
11	R2.F.01	Inappropriateness of budget estimate	Contractor	3	4	12	R.R.2	3	4	9
12	C1.C.05	Dispute resolution clauses	Contractor	4	5	20	R.T.1.01	4	5	12
13	C1.B.03	Delay in permits / approval	Client	3	4	12		3	4	12
14	C1.B.04	Delay in progress payments	Client	4	4	16		4	4	16
15	P1.C1.03	Lack of enough qualified personnel of client	Client	2	3	6		2	3	6
Total value						159				112
PRE.RESP.RATING						10.6				7.5
RISK CATEGORY					SIGNIFICANT				MODERATE	

Table (8) : Risk carting process sheet of Iraqi project A

WORKPACKAGE 4										
ESTIMATED COST=3*10^{9}ID										
PRE-RESPONSE							POST-RESPONSE			
NO	RISK CODE	RISK DESCRIPTION	OWNERSHIP	PROBABILITY	IMPACT	RATNG	RESPONSE CODE	PROBABILITY	IMPACT	RATING
1	R1.H.01	Strict health & safety requirements	contractor	3	3	9	R.T.1.02	2	2	4
2	D1.D.04	Complexity of design	Client	1	3	3		1	3	3
3	R1.E.01	Strict env. Requirements	contractor	2	2	4	R.T.1.02	2	1	2
4	P1.C1.01	Negative attitude towards foreign contractors	contractor	4	4	16	R.R.1.01	4	3	12
5	P1.C1.04	Vagueness of req / client expectation	contractor	2	4	8	R.T.1.01	2	2	4
6	P1.S.01	Unavailability of sub-contractor	contractor	2	5	10	R.R.1.01	2	4	8
7	P1.S.02	Poor performance sub-contractor	contractor	2	3	6	R.T.1.02	2	2	4
8	P1.C2.01	Poor performance of consultant	contractor	3	3	9		3	3	9
9	P1.P.03	Poor performance of PM staff	contractor	2	3	6	R.R.1.04	1	1	1
10	P1.P.05	Lack of experience of PM staff	contractor	1	3	3	R.R.1.04	1	1	1
11	R2.M.03	Unavailability of material	contractor	2	4	8	R.T.1.02	2	2	4
12	R2.M.04	Delay in material delivery	contractor	3	5	15	R.T.1.02	2	4	8
13	R2.E..06	Restrictions on imports	contractor	3	2	6	R.T.1.01	2	2	4
14	R2.L.02	Poor productivity of workers	contractor	3	3	9	R.T.1.02	2	2	4
15	R2.L.04	Restrictions on foreign workers	contractor	5	3	15	R.R.1.01	5	2	10
16	R2.F.01	Inappropriateness of budget estimate	contractor	2	5	10	R.R.2	2	4	8
17	P2.S.01	Physical constraints	contractor	3	3	9	R.R.1.01	3	2	6
18	C1.C.05	Dispute resolution clauses	contractor	4	4	16	R.T.1.01	3	3	19
19	C1.B.03	Delay in permits / approval	Client	4	5	20		4	4	16
20	C1.B.04	Delay in progress payments	Client	4	5	20		4	5	20
21										
Total value						202				147
PRE.RESP.RATING						10.1				7.4
RISK CATEGORY					SIGNIFICANT				MODERATE	

Table (9): Risk carting process sheet of Iraqi project A

WORKPACKAGE 5										
ESTIMATED COST=**$0.2*10^9$ID**										
PRE-RESPONSE							POST-RESPONSE			
NO	RISK CODE	RISK DESCRIPTION	OWNERSHIP	PROBABILITY	IMPACT	RATNG	RESPONSE CODE	PROBABILITY	IMPACT	RATING
1	R1.S.02	Inappropriate schedule estimate	contractor	4	4	16	R.T.1.02	4	3	12
2	R1.S.03	Unrealistic milestones	contractor	3	5	15	R.R1.01	3	2	6
3	R1.E.01	Working hour restriction	Client	3	4	12		3	4	12
4	R1.E.02	Strict quality requirements	contractor	4	4	16	R.T.1.02	4	3	12
5	D1.C.02	Strict health & safety requirements	contractor	3	2	6	R.T.1.02	3	1	3
6	P1.C1.01	Strict env. requirements	contractor	4	4	16	R.T.1.02	3	2	6
7	P1.C1.02	Delay in design	designer	2	5	10		2	5	10
8	P1.C1.04	Negative attitude towards foreign contractors	contractor	4	3	12	R.R.1.01	4	3	12
9	P1.S.02	Vagueness of req / client expectation	contractor	2	4	8	R.T.1.01	2	2	4
10	P1.C2.01	Unavailability of sub-contractor	contractor	3	4	12	R.R.1.03	3	3	9
11	P1.P.03	Vagueness in scope	contractor	2	4	8	R.T.1.01	2	3	6
12	P1.P.04	Poor performance of consultant	contractor	3	4	12		3	3	9
13	P1.P.05	Poor performance of PM staff	contractor	2	4	8	R.R.1.04	1	1	1
14	R2.M.04	Poor communication between parties	contractor	3	2	6	R.R.1.03	2	1	2
15	R2.M.06	Unavailability of materials	contractor	3	5	15	R.T.1.02	3	2	6
16	R2.E.01	Delay in material delivery	contractor	3	4	12	R.T.1.02	2	2	4
17	R2.L.02	Restrictions on imports	contractor	3	4	12	R.T.1.01	2	3	6
18	R2.L.04	Delay in delivery of equipment	contractor	2	4	8	R.T.1.02	2	3	6
19	R2.F.01	Restrictions on imports	contractor	2	4	8	R.T.1.01	2	3	6
20	P2.E.01	Poor productivity of workers	contractor	3	4	12	R.T.1.01	2	3	6
21	P2.S.01	Restrictions on foreign workers	contractor	5	4	20	R.R.1.01	5	4	20
22	C1.C.05	Inappropriateness of budget estimate	contractor	3	4	12	R.R.2	3	3	9
23	C1.B.01	Unfavorable weather conditions	contractor	3	4	12	R.T.1.06	2	2	4
24	C1.B.03	Physical constraints	contractor	3	4	12	R.T.1.01	3	3	9
25	C1.B.04	Dispute resolution clauses	contractor	4	5	20	R.T.1.01	3	4	12
26	D1.D.03	Delay in permits / approval	Client	4	5	20		4	5	20
27	D1.D.04	Delay in progress payments	Client	4	5	20		4	5	20
Total value						340				232
PRE.RESP.RATING						12.6				8.6
RISK CATEGORY					SIGNIFICANT				MODERATE	

Table (10): Risk carting process sheet of Iraqi project A

WORKPACKAGE 6										
ESTIMATED COST= $0.1*10^6$ID										
PRE-RESPONSE							POST-RESPONSE			
NO	RISK CODE	RISK DESCRIPTION	OWNERSHIP	PROBABILITY	IMPACT	RATNG	RESPONSE CODE	PROBABILITY	IMPACT	RATING
1	R1.S.01	Inappropriate schedule estimate	contractor	2	2	4	R.T.1.02	2	2	4
2	R1.Q.01	Strict quality requirements	contractor	3	3	9	R.T.1.02	3	2	6
3	P1.C1.01	Negative attitude towards foreign contractors	contractor	4	4	16	R.R1.01	4	4	16
4	P1.S.02	Vagueness in scope	contractor	2	3	6	R.T.1.01	1	2	2
5	P1.C2.01	Poor performance of consultant	contractor	2	2	4		2	2	4
6	P1.P.03	Poor performance of PM staff	contractor	1	2	2	R.R.1.04	1	1	1
7	P1.P.04	Poor communication between parties	contractor	2	3	6	R.R.1.03	1	2	2
8	R2.M.04	Delay in material delivery	contractor	3	3	9	R.T.1.02	3	2	6
9	R2.M.05	Restrictions on imports	contractor	3	3	9	R.T.1.01	3	2	6
10	R2.M.06	Improper material definition	Client	2	4	8		2	4	8
11	R2.E.03	Delay in equipment delivery	contractor	2	3	6	R.T.1.02	2	2	4
12	R2.E.06	Restrictions on imports	contractor	3	5	15	R.T.1.01	3	4	12
13	R2.L.02	Poor productivity of workers	contractor	4	4	16	R.T.1.01	3	3	9
14	R2.L.04	Restrictions on foreign workers	contractor	5	3	15	R.R.1.01	4	2	8
15	R2.F.01	Inappropriateness of budget estimate	contractor	3	5	15	R.R.2	3	5	15
16	P2.S.01	Physical constraints	contractor	3	4	12	R.T.1.01	3	2	6
17	C1.C.05	Dispute resolution clauses	contractor	4	5	20	R.T.1.01	3	4	12
18	C1.B.03	Delay in permits / approval	Client	4	4	16		4	4	16
19	C1.B.04	Delay in progress payments	Client	4	5	20		4	5	20
Total value						208				157
PRE.RESP.RATING						10.9				8.3
RISK CATEGORY					SIGNIFICANT				MODERATE	

After final risk rating and corresponding response cost values of each work package are obtained, first part of the RC process is completed. As stated, the rating value does not mean anything by itself. Therefore, final rating value is converted to linguistic term and categorized as low, moderate, significant and high (more details are available in Table (11). Linguistic terms represent the situation better than rating values alone and facilitate to understand risk level of the work packages. IRMS report engine provides a tabular report which summarizes the first part of the RC process, contains whole important values and items of the project risk rating. The summary

output of the project risk rating of the Iraqi project A is given in Table 12. The other two projects B and C are summarized in Tables 13 and 14.

Table (11): Rating score ranges and corresponding rating curves (9)

Rating score range (K)	Risk rating curve	Risk category
1-5	<y=5/X	Low
5-10	y=5/X < RS < y=10/X	Moderate
10-15	y=10/X < RS < y=15/X	Significant
15-25	Y=15/X < RS	High

Table (12): RC process project risk rating summary output (project A)

Work package	Pre-response rating value	Post-response rating value	Final risk level*
WP1	SIGNIFICANT 10.9	MODERATE 7.1	MODERATE
WP2	SIGNIFICANT 11.9	MODERATE 7.9	MODERATE
WP3	SIGNIFICANT 10.6	MODERATE 7.5	MODERATE
WP4	SIGNIFICANT 10.1	MODERATE 7.4	MODERATE
WP5	SIGNIFICANT 12.6	MODERATE 8.6	MODERATE
WP6	SIGNIFICANT 10.9	MODERATE 8.3	MODERATE

***its value equal to post-response rating values**

Table (13): RC process project risk rating summary output (project B)

Work package	Pre-response rating value	Post-response rating value	Final risk level
WP1	SIGNIFICANT 10.6	MODERATE 7.8	MODERATE
WP2	SIGNIFICANT 10.9	MODERATE 7.6	MODERATE
WP3	SIGNIFICANT 10.3	MODERATE 6.8	MODERATE
WP4	SIGNIFICANT 9.1	MODERATE 7.6	MODERATE
WP5	SIGNIFICANT 11.6	MODERATE 8.8	MODERATE
WP6	SIGNIFICANT 11.9	MODERATE 8.6	MODERATE

***its value equal to post-response rating values**

Table (14): RC process project risk rating summary output (project C)

Work package	Pre-response rating value	Post-response rating value	Final risk level
WP1	SIGNIFICANT 10.9	MODERATE 6.1	MODERATE
WP2	SIGNIFICANT 11.9	MODERATE 6.4	MODERATE
WP3	SIGNIFICANT 10.6	MODERATE 6.4	MODERATE
WP4	SIGNIFICANT 10.1	MODERATE 7.8	MODERATE
WP5	SIGNIFICANT 12.6	MODERATE 7.7	MODERATE
WP6	SIGNIFICANT 10.9	MODERATE 7.7	MODERATE

***its value equal to post-response rating values**

Conclusion

A risk management process has been developed as well as a risk information so that IRMS can be used for systematic management of risk by all parties involved in three Iraqi construction project projects; rebuilding, high-ways, building). Major functions of IRMS include, risk analysis by Monte Carlo (MC) simulation (probability and rating degree), risk assessment by risk rating, risk re-assessment, response generation. Risk carting (RC) processes are reduced from high risk management to moderate ones for the three project cases.

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