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Interactive risk management approach: a simulation game Ã¢ RIGÃ¢

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Interactive Risk Management Approach:

A Simulation Game "RIG"

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ABSTRACT

Oil and gas projects require extensive experience in project management in order to successfully fulfill project objectives. A number of computer-aided tools have been developed and became effectively used in educating students and training engineers on different aspects of the project management domain. However, none of these tools have been developed specifically for the petroleum industry although it incorporates high-risk standards requiring well-trained engineers on risk management. The objective of this research is to introduce the concepts of risk management to different participants involved in the oil and gas industry, increase their awareness for the vital need for proper risk assessment in addition to providing them with an educational tool to enhance their capability for efficiently managing risks associated with their projects. A computer simulation tool is developed in the form of a game for the purpose of training and enhancing engineers' capabilities in risk management. The tool named RIG (Risk management Interactive Game) simulates the construction phase for a petroleum development project involving the effect of the different risk factors on the time and cost of the main project milestones: procurement, fabrication and installation. The project involves installing an offshore platform and the required pipeline for exporting the production to the onshore treatment facilities. RIG was evaluated through: performing multiple runs and replications and performing sensitivity analysis to check the validity of the model with its results; in addition to testing on less experienced engineers to validate its simplicity, comprehensiveness and applicability as an educational tool to enhance their skills. Findings show that RIG can contribute in risk management training in addition to decision-making skills for petroleum projects and the model was successfully giving very good results reflecting reality. The sensitivity analysis was performed to validate the model and the findings were that the main variables having the great impact on the final profit were the contingency percentage and the preventive actions decided by the user; and the analysis proved that increasing the contingency percentage would increase the final profit but to a certain limit unless proper risk identification was performed. Additionally, the most significant preventive actions were determined for the chosen sample project.

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ACKNOLEGMENTS

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I dedicate my work to my kids wishing they could do better in their lives than I did in mine.

CHAPTER ONE:

INTRODUCTION

A. Project management

Construction project is a multidisciplinary activity that encompasses: 1- many parties with decisions impact on the project; and 2- tasks to be done along with their related factors on either cost or time (Chan and Park 2005). Consequently, acceptable and professional management for the project from early stages of planning and design is a very critical and imperative for the success of the project.

Project management is the tool where a skillful engineer should implement in order to achieve the owner's desired requirements and wishes through some skills and techniques. Project management process should involves planning, executing, controlling and monitoring the project's scope, schedule, cost and quality (PMBOK 2009).

In large-scale projects, as well as complicated projects, project management is a vital mission especially for projects that require highly technical approaches such as oil and gas development projects. In addition to that, for such multi millions investment projects, a project manager should be acquainted with the latest technological tools and skills in different aspects of managing and controlling the project budget. In general, the project manager should be involved in the following project activities:

1) Developing an overall plan,

2) Defining the scope of work to be completed,

3) Breaking of the scope into activities or deliverable packages,

4) Preparing and following up the duration and cost for each activity,

5) Managing and controlling quality.

6) Planning and managing the certain threats as well as accounting for the anticipated uncertainties in risk management process.

Project management under uncertainty has not became as good as expected through recent decades (Weaver 2010). For instance, as indicated by Weaver (2010), a research on the risk of delay had been done including some of the mega projects. The research findings stated that most of the mega projects failed in the time management process especially for monitoring and control. Moreover, most of the construction companies, from the performed survey, have usually planning schedule only for winning of the bid purpose not to control and manage the project execution. In that survey, it was noticed that, in oil and gas industry, only 19% of the projects were completed within or ahead of the planned schedule. Additionally, about 74%of the oil and gas projects were completed with a delay from the planned schedule of about 3 months, and that should be considered seriously since the research was based on a recent survey that was conducted in between December 2007 and January 2008. In addition to that, another research finding from that survey was that engineers need more training and well education in project management, especially time management under uncertainty, either in undergraduate courses, post graduate or training hired engineers. Noticing that, failure in time management in oil and gas projects has a major impact on the overall investments and the total budget of these projects as investment projects related to production.

It is worth mentioning that, training engineers in the different branches and activities of project management is a must especially on-site training. On the other hand, on-site training requires high safety precautions; and we must keep in mind the difficulty of getting security permits for any visitors to any offshore petroleum site.

B. Risk Management

Knowing that, risk is the event, which is likely to adversely affect the project objectives. Moreover, risks are what may cause losses with impact on investors. Risk can be characterized in terms of its severity; where:

Severity = Likelihood of occurrence * Magnitude of the impact (1)

Risks can be reduced and sometimes transferred through different methodologies such as: contracts, financial agreements, insurance policies, etc.; and these methodologies can be recognized through Risk management process. Consequently, Risk management has become a necessary task and inevitable in almost all types of projects. Risk assessment should be implemented whenever there is a threat or anticipated hazard whatever the expected impact of that hazard would be (Aven 2011). In order to achieve a good quality risk assessment study, as shown in figure (1), a certain procedure has to be followed. First, Risk management planning through deciding how to approach, plan and execute the risk management activities for the project. Second, identifying possible risks associated with the project and the probabilities of risks to materialize. Third, risk qualitative analysis and prioritizing risks according to their severity, then quantitative analysis by creating the models and analyzing the risk impact on the overall project objectives. Fourth, reducing threats through risk response planning by deciding the proper control measures along with their impact. Finally, the decided control measures can be implemented, supervised and reviewed frequently along the project time, through a risk monitoring and control.

Risk Management:

Figure (1) Risk management procedure

Considering the nature of the petroleum development projects, risk assessment cannot be ignored as one of the project manager's planning and monitoring vital task. The main reason for that is the risky nature of the petroleum development site and the equipment that is used either in construction or in operation. Petroleum development projects, either onshore, or offshore, usually encounter many unique risk factors, but most of the risk assessment studies performed in real practice mainly concentrate on health, safety and environmental risks and their precautions. However, during construction, risk factors are not less important and project managers have to be well prepared for them through planning. Theoretically, a Total Risk Assessment "TRA" can be performed in the planning phase of any project (Vinnem 2007), then after the design is almost finished, the Quantitative Risk Assessment "QRA", a Hazards and Operability study "HAZOP" can be performed, as well as safety and operability study "SAFOB" by the Health and safety teamwork. Many risk factors were investigated and analyzed for different types of construction projects including petroleum projects in literature (Mbachu 2005). For instance, risks may occur as a result of inadequate planning, poor resource allocation, poor definition of the project scope, errors in estimating time or resource availability affecting procurement delivery in proper time, cost estimation errors, inadequate productivity or lacking of cost control. Such risk factors should be preplanned and then monitored since they have impact on both the project schedule and total budget. For research purposes, many approaches are used for "QRA" analysis as explained by (Aven 2011), but the commonly used approach for analysis is the probabilistic analysis. In the usual practice it is to use information based technology on both company's database and teamwork experience.

C. Computer simulation tools

Using computer in educating and training students the principles of project management started may be as early as 1969 as a part of the learning process (Mekkawi 2006, Nassar 2001). In recent years, computer and the Internet have become widely used either for gathering information or playing games (Yaoyuenyong 2005). Moreover, computer aided programs have became the newly innovative tools in educating and training engineers; although still not widely used in Egypt; to cope with the real life problems.

Many computer-aided tools were developed for the purpose of training and / or educating engineers on different aspects of project management worldwide. The reason of developing such tools is that classroom environment can be depicted as boring unless teachers utilize some innovative ideas and tools to promote enthusiastic learning in class and make classroom environment more attractive (Mekkawi 2006 and Nassar 2001 agree on that). And as Allery 2004 agreed with the idea that innovative approaches in education have became more applied in practice, simulation tools can be considered as important part of these approaches although some researchers are questioning the effectiveness of these tools in education (Al-Jibouri 2001). However, Al-Jibouri agrees with Sawhney and others that students learn more effectively when they can participate in the learning process as a self learning process (Doloi 2008); "learning by doing" is a very common sentence in the education literature and most researchers agree on that (Sawhney 2001, Allery 2004, Al-Jibouri 2001). Additionally, traditional teaching methods are not sufficient for engineering students to be able to deal with real life problems and take the right decisions (Sawhney 1998, Al-Jibouri 2001).

What should be considered is that: on-site training is very essential for training engineers on dealing with real life problems and visualizing what they were learning in class, in spite of the difficulty of finding accessible site and safe environment for training. The computer programs that are used for the education and training tools aim at reducing the complexity of real life in-site difficulties to become simple enjoyable game to play and get scoring for the decisions that were taken during the game's levels or stages. Accordingly, using games as training tool for project managers has a potential advantage which is making training fun and encouraging to become higher professionally skilled. Accordingly, if the game provides fun to students during learning, simulation provides reality from many repetitions (Sacks 2007) and that could be the reason of why simulation games can be considered as a powerful tool for educating students, training engineers, decision support system or research purposes.

D. Problem statement

Oil and gas projects, in real practice, are usually facing many risks requiring the implementation of successful risk assessment procedure, which is actually done, but sometimes limited to health, safety and environmental risks. Training engineers on risk management requires both in class education for the basics and on-site training for real life experience. However, on-site training is very difficult especially for offshore projects requiring special permits, in addition to the risky environment for less experienced engineers. Therefore, using educational tools for on-site training could be a better alternative. The available educational and training simulation tools are usually limited for a certain activity or certain construction projects and nearly none of the available tools discussed the construction phase of a petroleum development project.

E. Objective

The objective of this research is to introduce the concepts of risk management to different participants involved in the oil and gas industry, increase their awareness for the vital need for proper risk assessment in addition to providing them with an educational tool to enhance their capability for efficiently managing risks associated with their projects. A computer simulation tool is developed in the form of a game for the purpose of training and enhancing engineers' capabilities in risk management. The tool named RIG (Risk management Interactive Game) simulates the construction phase for a petroleum development project involving the effect of the different risk factors on cost of the main project milestones: procurement, fabrication and installation. The tool is targeting less experienced engineers working in the field of the petroleum projects.

F. Research methodology

In this research, a training tool RIG was developed to simulate an oil and Gas development project for training less experienced engineers on risk management through risk management methodology. The tool can act as a decision support system for the real-life used data and the embedded model. The research methodology was as follows:

1- Problem definition.
2- Investigating the existing educational tools through literature.
3- Defining the scope of the research and the model that will be used in developing the tool.
4- Gathering the required technical data through a petroleum company's database and interviews with professional petroleum engineers to ensure providing realistic results.
5- Developing the educational tool by using a simple programming language that provides visual and interactive models "flash".
6- Testing the tool through performing a number of simulation iterations "model validation".
7- Testing the tool through a number of engineers "expert validation".
8- Conclusion and recommendations for future improvements.

Noticing that, the main goal while developing the research methodology is the mapping between the risk management basics and the research methodology. Therefore, the approaching procedure was followed as shown in figure (1), which is matching the usual followed risk assessment process as explained in PMBOK (2009).

Risk Management in RIG tool:

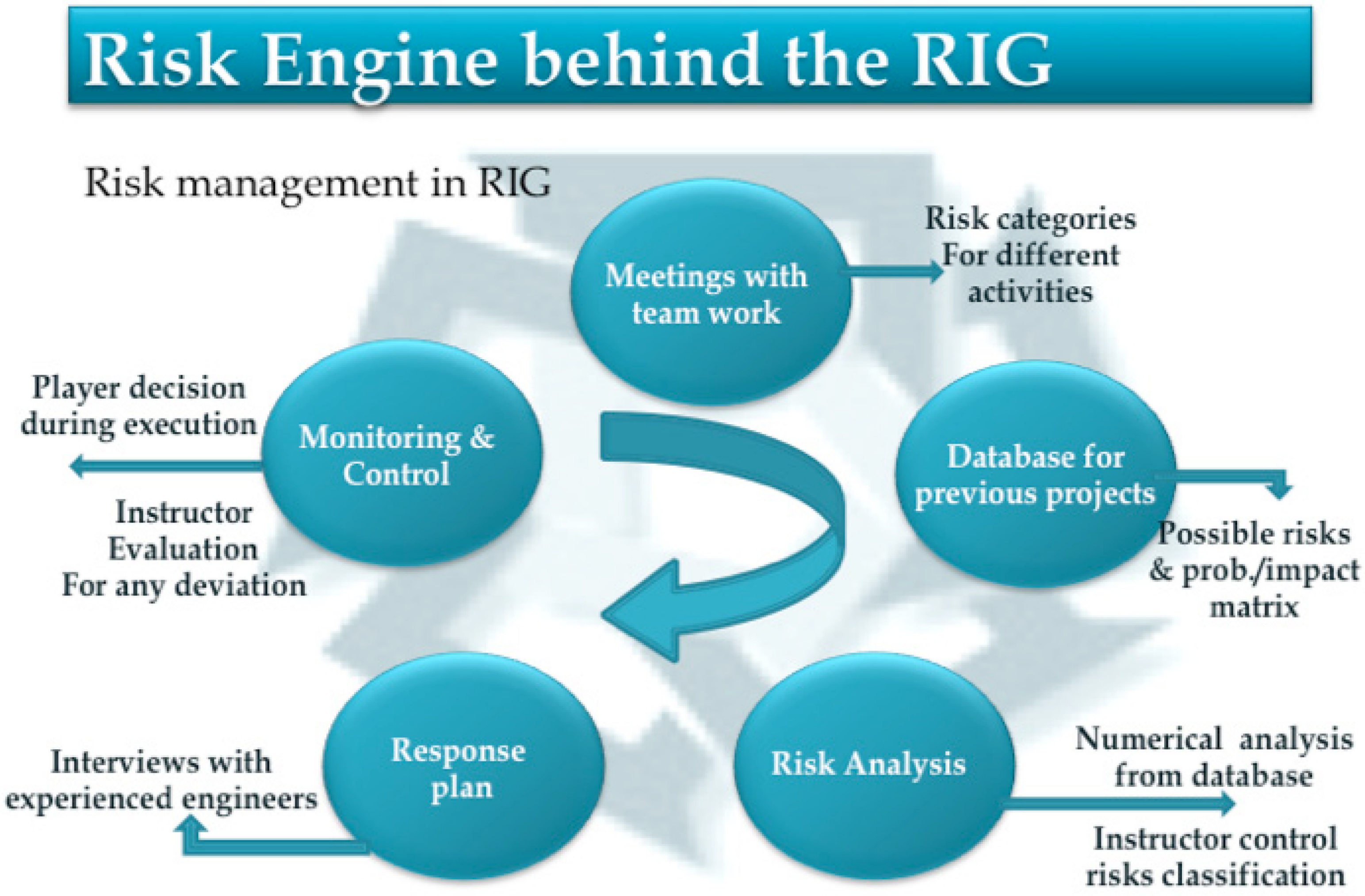


Figure (2) Research methodology and risk mapping

As shown in figure (2), the risk procedure followed in RIG tool was started by a number of meetings with experienced engineers in petroleum companies, then building the risk probability / impact matrix from the gathered data. After that the risk numerical analysis was performed and finally the response measures and different decisions were gathered through other meetings with experienced engineers in risk management from petroleum companies.

In this research, training engineers for planning and managing risks in an uncertain, realistic, but safe and joy-able environment are the main tasks. Risk management Interactive Game "RIG", which is an educational game, was developed for training engineers how to manage risks for the construction phase of an offshore petroleum development project. Subsequently, it was evaluated through: performing a simulation of 500 iterations in addition to sensitivity analysis for validating the model, and then was tested and evaluated by engineers working in a petroleum company with a working experience of two to five years.

G. Choice of petroleum project model

The choice of petroleum project model triggered from two main reasons: first almost no training tools were found in literature discussing the construction risks in petroleum projects, and second training petroleum engineers on risk management in real practice is mainly concentrating on health and safety precautions and regulations. Noticing that, the main goals in a petroleum development project are to start production as early as possible, embrace high quality as well as safety. Petroleum projects, in real practice, are usually facing many risks requiring the implementation of successful risk assessment procedure, which is actually done, but sometimes limited. Occasionally, in practice, a hedging plan is used in order to either eliminate the risks or minimize them. Therefore, it could be concluded that risk management is one of the highly vital factors that could have a great influence on the petroleum project objectives. However, in reality, health and safety risks are the main concerns when the risk assessment is performed. Some risks may occur during construction, and therefore, the project manager has to be well trained to recognize how to mitigate those risks and/or prevent them.

The chosen model’s main tasks are to procure and install a production platform of prefabricated steel panels and the required offshore pipeline that transfers the production to the onshore treatment facilities. Despite that the project's milestones are usually in practice divided into four phases: design, procurement, construction and commissioning, the developed tool is, principally, focusing on the construction phase and the effect of the procurement phase on the project execution.

CHAPTER TWO:

LITERATURE REVIEW

A. Introduction:

First, to clarify the difference between the two terminologies, simulation versus gaming: Allery (2004) has defined them as follows:

"Simulation: any structured experience designed to reflect reality, real life and real situations. Game: a competitive activity with a prescribed setting, constrained by rules and procedures. The learning results from playing the game (e.g. interactions and behaviors exhibited) and not from the academic content or specialist subject matter". Moreover, Allery (2004) has defined the integration of simulation and game as it would represent a reality based enjoyable tool offering the contribution of real life experience and joyful learning in one tool. Meaning that, learning through simulation games can be more effective and giving better results since students would remember the information they learned through games more than they got in the usual class environment and on that Klassen and Willoughby (2003) agree with Allery (2004).

Most of the different simulation games that were developed for the purpose of education and training in management were usually aiming at simplifying the real life problems into a fun game and most of which were evaluated by the players themselves through the game scoring system. The game builders have recently added the web-based tools to the game to benefit from the Internet possibilities in sharing ideas and teaching students to work in team environments. Additionally, web-based tools facilitate the access of widely available information databases and allow the exchange of information among professionals around the globe (Sawhney 2001). A very good description for playing serious games was found in literature by Juul (2005) that he considered that as much alike to "interact with real rules while imagining a fictional world" (Juul 2005). From that description, educational games educating construction management are providing the real basics of management while embedding mathematical equations for presenting the real on-site situation through visual and interactive animations.

Simulation tools are not a new concept to be used in construction management education and training; they have started maybe early in 1969 by Au (Au, et al. 1969). (Bilsen 2010, Agapiou 2009, and Nassar 2001) agree that, simulation games can be useful tool in training and providing graduate students with the required management skills through practicing and may be experiencing a simulation to real life problems. However, Nassar (2001) argues that simulation tools cannot replace the formal class meetings for teaching the theories and different methodologies. Additionally, a simulation to real life problems may ignore some variables that cannot be simulated (Nassar 2001); human behavior can be an example for that since it is hard to be expected.

Some simulation models have been developed for evaluating and analysis of some management basics considering risk management. For instance, CSRAM model (Okmen and Oztas 2008) has been developed for evaluation of a building schedule under uncertainty. The model considered the effect of different risk factors considering the relationship between activities, and the relationship between activities and risk factors. Another educational tool was targeting the planning and control phases for a dam construction project (Al-Jibouri 2001) concentrating on one skill for student to gain, but with multiple activities in building a dam.

However, no simulation tool could be found in the literature aiming at teaching students the basics of construction management for a petroleum development project. Most of the discussed topics mainly concentrate on the exploration, production and operation phases. Additionally, risk management in the petroleum sector is very essential and crucial that has to be implemented in all projects starting from the design drawings issuance. Noticing that, in literature, risk management mainly concerns about the risks of the discoveries, well production technical or geological problems, or health, safety and Environment "HSE", and Hazardous and Operability "HAZOP". This may be considered as a normal case since petroleum site is unique and requires high safety standards because there are many risk factors, which jeopardize health and environment that may caused by accidents, leaks or even human errors. However, in the construction phase of petroleum projects, construction risks can happen. Consequently, unique project can have some unique risks to be added to the usual risk factors, and that is the importance of the gathering information from previous and similar projects triggered from.

a. Existing computer simulation tools

In recent years, many computer-aided tools have been used in order to assist the education and training process aiming at providing students and engineers with the required experience, knowledge, information and skills (Tserng 2008). The developed tools are either targeting a certain activity of the construction process, a specific skill of the project management basics, or sometimes integrating altogether as a level of complexity. Some simulation tools integrated the web based tools to benefit from the construction database available on the Internet providing a wide base for information and knowledge (Tserng 2008), in addition to utilizing the available database on the Internet in an interactive learning system (Sawhney 2001). The potential outcome from using the Internet database is to ensure that the tool is simulating reality.

Some of the recent developed tools can be discussed as follows:

1- Easy plan: (Hegazy 2006) a game called Easy plan that was developed for teaching project management basics and time/cost control: the contractor needs to decide the bid value according to the given data such as schedule, resource limit per activity, indirect costs, penalty for delay per day and markups. The contractor can get the schedule optimization "planned versus actual". Although the model gathered more than one of the project management basics as a self-training model for students, which is very effective training idea, the model visual and interactive features cannot be considered as a joyful educational game. Moreover, many commercial software exist now can give similar results in case of using example projects prepared and saved in the program database such as Primavera.

2- CAL tool: "Computer Aided Learning tool" (Mekkawi 2006) is a game assessing the decision making during construction phase for the excavation activity. The concentration on one activity could be considered as an advantage only in case of covering all the related and different methodologies and equipment used. Moreover, students can rectify decisions which may not the best way for reflecting reality, although it may teach them why their decisions where wrong and how to correct that. However, rectifying the player's decisions is contradicting one of the tool's objectives, which is reflecting reality where there is no turn back and changes the decisions taken. Measuring time, cost and quality are seemed to be like counters not as schedule or cost control. Therefore, the CAL tool is for training students on a specific activity and one aspect of the project management basics teaching.

3- SimPort Game: "A Simulation Game about Planning a Port Area" (Bilsen 2010) is teaching planning of on-site construction activities for a port area while stressing problem solving skills and team working. It was developed in Delft University of technology in 2004/2006. Then, Henesy (2008) made some modifications on the SimPort in order to use the simulation as a policy evaluation for the port operational decisions. Such modifications can be very useful and effective making the simulation tool a multipurpose tool that can be used in educating, training and decision support system. The main advantage of the SimPort game that possibly made it interesting is that the players are involved in all the decisions related to the construction of the new port in addition to the operation of the existing ones. Noticing that, the lack of communication between players is the main problem that they may face. Therefore, activity needed is full coordination between them in addition to a strategic plan to be prepared.

4- SIMPLE: "SIMulated Professional Learning" (Agapiou 2009) is teaching the basics of team working and decision-making skills in contract management. The main purpose of the simulation game is teaching students decision-making skills and team working concentrating on the contract management task through the construction activities of a certain building contract. Going through the literature, the game seems to be like a questionnaire more than an interactive teaching visual game, especially when comparing by other simulation games.

5- PMT: "Project Management Trainer" (Davidovitch 2006) is training engineering students and managers project planning, management basics and decision-making skills through history keeping. The game is aiming at managing time through planning, meeting schedule and managing costs.

From literature, it could be considered as a privilege in this simulation game that the student can analyze his decisions and chosen scenario by using commercial project management software, since there is a sort of integration between the commercial software and PMT. However, it should be considered that recent commercial software updates have integrating many project management basics and tools in a simple interface for clients to be satisfied with this software and do not need to use another one. From the point of training and educating students, other features could be added to PMT to differentiate it from any other commercial software and make it more attractive for the learning purposes, and that could not be only achieved through history keeping since commercial software offers this tool as well. Final notice, student has the ability to perform undo for any step for the education purpose, but this contradicts with the preparation of students to real life problems where there is no undo in taken decisions.

6- VCON: "Virtual Construction Negotiation Game" (Yaoyuenyong 2005) is training students on negotiation skills in construction contracts. The user or the trainee has to have a good background of construction management basics, contract types, payment methods, and bidding. Therefore, mainly graduate students are the main target trainees by this simulation game, or may be senior students. Using on-line methodology for playing the game can be an encouraging factor for the trainee during negotiation and less tense. However, giving a helping tool in management basics information can be very useful for the player to decide which type of contract to choose and why, for instance.

7- C^3M: “Construction Contracts in a Competitive Market” (Nassar 2002) is teaching the tradeoff between the bid price and market share in a competitive way. The main advantage of the simulation game is that it could teach students the meaning of the market share and thinking well when deciding the bid price, since it should not be a one-job decision. Concentrating on one pay item, maybe was aiming at clarifying the idea, but needing more engineering details for students to decide the bid price according to engineering management basics such as equipment, construction methodologies and other activities, which can add more complexity and reality to the game. Moreover, visual interface was very simple and limited.

8- PARADE: (Han 2011) is teaching the dynamics of the construction production systems. Although the game, as mentioned in literature, is internet-based, but it should be played in class and the students' decisions should be interpreted and justified by the instructor through the game results just after finishing the game. Additionally, level of difficulty can be managed through the instructor by some given information just before playing the game. Therefore, making the game internet-based is useless unless the instructor can control and/or change the given data through the web in addition to the discussion or analysis of results methodology.

9- The tutorial: "Interactive multimedia case study" (Nassar and Al-Khatib 2002) is teaching legal concepts of construction law. The game mainly concentrates on the legal relationship between the owner and the contractor and some basics on how decisions can impact this relationship and sometimes on the contractor's opportunity of future contracts. Change order, disputes and contract clauses are some of the basics that are included in the game. The main idea is good and helpful, but it could be more effective if exposed to full contract types and clauses.

10- Scheduling Tutorial: (Nassar 2001) is teaching planning, scheduling and control basics for construction projects. The main disadvantage of the game is the many steps required from the user; in addition to that it may not be easy and require some assistance from the instructor to know how to play it. However, the scheduling game is very effective and proved a successful tool as self-training because it can be described as a "methodical tool" that accumulates almost all the scheduling aspects in an interactive way.

11- CSRAM model: (Okmen and Oztas 2008) is evaluating a building schedule under uncertainty. The model considered the effect of different risk factors in view of the relationship between activities, and the relationship between activities and risk factors. The CSRAM model's objective is to develop a simulation risk analysis tool and is considered as a decision support system. The model requires a qualitative input data from the user to: identify the risks, the probability of each risk factor and the impact on schedule. Noticing that, the schedule can be considered another input data required from the user, as it is unique for every project. Simulating reality can only be achieved in case of realistic input data. Additionally, the CSRAM model depends on the experience of the user and his skills in identifying the possible risks and their impact. Noticing that, the model concentrates only on the impact of risks on schedule, and nothing is considered for their impact on the project budget. It can be considered as a simple tool helping the project manager in the scheduling process in order to account for the expected risks in the planned schedule.

Simulation tool	Purpose	Required user level	Programming platform	Self training	Visual/interactive	No. of users	Additional information
Easy plan	Project management basi & time/cost control	Undergraduate & graduate students	Excel-based mo	Applicable	N/A	Single player	———
CAL tool	Decision making during construction phase of excavation	Undergraduate students	C^{++}	Applicable	Applicable	Single player	Helping tool and consultant
SimPort	Problem solving skills an team working in plannin construction activities fo port area	Graduate student	Not clarified in literature	Applicable	Applicable	Multi-player	Students can save their work and proceed later
SIMPLE	Team working and decisi making skills in contract management	Undergraduate students	Not clarified in literature	Applicable	Applicable	Multi-player	Help through libr and saved docum
PMT	Project planning, management basics and decision-making skills through history keeping.	Undergraduate students and proj managers	Not clarified in literature	Applicable	Applicable	Single player	case studies datab & integrating commercial softw
VCON	Negotiation skills in construction contracts	Graduate student	Not clarified in literature	N/A	Applicable	Multi-player	Online game and provide levels of difficulties
C^3M	The tradeoff between the price and market share in competitive way	Undergraduate students	Not clarified in literature	N/A	Limited	Multi-player	———
PARADE	Dynamics of the construction production systems	Undergraduate students	JAVA	N/A	N/A	Single player	Internet based, bu requires instructo assistance
Interactive multimedi case study	Legal concepts of construction law	Undergraduate students	Flash	Applicable	Applicable	Single player	———
Scheduling tutorial	Planning, scheduling and control basics for construction projects	Undergraduate students	Flash	Applicable	Applicable	Single player	Internet based
CSRAM	Evaluation of a building schedule under uncertain	Experienced engineers	Excel & @Risk	N/A	N/A	Single player	———

Recent Developed tools (1)Table

CHAPTER THREE:

MODEL DEVELOPMENT AND CHARACTERISTICS

A. Introduction

Time is not money as concluded in literature through the research survey findings by Weaver (2010). The meaning of that is money if not used it still exists or may be increased by interests if saved in a bank, but time if not used it just passes by and never comes back. Hence, time should be used not wasted and well managed for avoiding uncertainties. Noticing that, failure to fulfill the project in the planned time, for mega investment projects, would have a major impact on the final markup too. Risk management procedure in the petroleum projects has to follow the same main steps: risk planning, risk identification, risk analysis, and finally control/monitor the implementation. Before starting the RIG model development, a similar procedure to the risk management process was followed. Many possible risks may sometimes materialize in oil and gas development project's construction site causing losses in the project's total budget and/or delay in the schedule. However, almost only professional engineers with many years experience in the field can anticipate such uncertainties and deal with most of them. Consequently, training graduate engineers how to manage uncertainties can be more effective in order to prepare them to expect, prevent or mitigate, then monitoring and control threats, which is the main objective of the RIG tool. Identifying the main objective of the RIG tool in a model is the basic foundation for developing it. The RIG tool is developed by using a group of mathematical models comprising some equations of the main variables or factors that have the major impact on the project mark up.

The first vital issue that was considered when developing the RIG model was identifying the risk factors affecting the project final cost. From literature, many researchers were developing models to estimate the impact of the different factors while calculating the project's cost (Chan and Park 2005). These factors may include type of contract, type of project, required technology, importance of the project to be completed in time, staff level needed, equipment availability, and many other factors that are related to the cost directly or indirectly. Additionally, the uncertainties that may exist or occur during the execution phase are very important that have to be considered as well. Therefore, the factors that were considered are the main factors having the major impact on the total cost of the project; noticing that the impact on time could be translated as losing profits per day in future modifications. The main factors that were considered are uncertainties impact, contingency value including the markup, in addition to any management decisions to prevent or mitigate the uncertainties.

The developed model RIG characteristics are: single user, and multi try model since the user can try it as many times as he/she needs, but he may win or lose the game "non-zero sum" through gaining profits or losing all the investments. To gain or lose in the RIG model is a result of the taken decisions and the impact of risks encountered during the project. The model is interactive as it reacts according to the users' decisions and it has visual videos that clarify the construction activities as if the users are in a construction site. The RIG is developed to be a self-learning tool. Therefore, a narrative part was added before starting the project execution explaining the purpose and the components of the project, in addition to the helping tables providing the user with some useful information before and during the game. Noticing that, the narrative part text is saved in separate files and can be edited to change the given data for the students as a clue regarding the project uncertainties. The RIG tool is time scaled and the whole game can be over in about 20 minutes in the first time to read the narrative part carefully and it can be finished in about 15 minutes if played again by skipping the narrative screen.

The programming language used is the "Flash script". The reason for choosing Flash as the programming platform of RIG tool is because it is simpler than other programming platforms in developing games. Additionally, it is known in the market as a multimedia programming platform used to add: simple animation tools, videos, in addition it can interact with web pages, and is commonly used in developing games and animation advertisements on web sites.

B. The model input data

The data was gathered through the following steps: the first step: a sample offshore project was chosen from the historical database of a petroleum company. Second a number of meetings were performed to make a survey on the possible risks on an offshore project and the probability of each risk to occur. The third step, a questionnaire form was prepared including the main activities and the possible risks of which the project managers were requested to determine the impact of the risks on these activities. Then, in the meetings with professional project managers in one of the largest petroleum companies in Egypt it was agreed that it could be more conveniently to get the data from the company's historical database to be more realistic. Therefore, the main data of the model is based on historical database of the company in addition to the brainstorming in the meetings held with experienced project managers regarding the risks faced and the most effective preventive and/or mitigating actions to be considered. The impact of the preventive and mitigating actions in addition to the impact of the risks themselves on both cost and schedule of the project may vary from one project to another in addition to the market condition and many other variables. Therefore, for simplification purposes, only three variables were considered in the RIG model for a chosen sample project from the historical database of a petroleum company. The variables are: the contingency value, the response decisions for preventing risks from occurring, and decisions for mitigating uncertainties. The model input data that were gathered are as follows:

1. ***Project main data & design outcomes***

The project model is the construction of an offshore production platform with the required equipment for production on the Deck and a 30 kilometers offshore pipeline with a diameter of 16 inches. The design outcomes of the sample project are shown in Appendix A: table (1) and the design basics were assumed based on a previous project database since they should depend on the expected production and according to the well results. The sample project planned activities are shown in Appendix A: tables (2) and (3) along with the planned duration for each activity, the float, and the cost per activity. The tables are showing, additionally, the start date and end date for each activity, which can be used to prepare a detailed plan using professional computer project management tools such as Primavera or Microsoft project if needed. The activities were divided into five groups that are presented in the game as the five main "RIG activities" of the project, which are: Fabrication, Survey, pipeline installation, Platform installation and commissioning and start up. The relationship between activities was assumed to be finished to start in the game coding for reducing mathematical expressions and focus on the main purpose of the game which is the risk assessment while building the required models for the game. The reason for that is the availability of many commercial software exist that covered scheduling part very well with many models embedded as editable examples as well for training. Noticing that, the engineering activity duration is assumed to be zero days since it has no effect on the developed model, and the model is only focusing on the construction execution phase. From the tables (1), (2) and (3) the total project cost is $ 60MM, and the total duration of the project is 1179 days.

2. *List of possible risk factors*

The data of possible threats was gathered through meetings with four experienced projects managers with a field experience of about fifteen to twenty years at two of the major petroleum companies in Egypt using a prepared empty form as a questionnaire in a form of a table. Additionally, project managers provided data based on the historical database from previous offshore projects, and therefore the next tables (2, 3 and 4) were generated:

Activity ♦	Receiving material at fabrication yard		Surveing equipment approach		Loadout prefab. Material		Platform installation		P.L. Installation		Commissioning and startup	
Risk Factor / Impact ♦	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule
Intervention Works	18.52%	8.03%	17.56%	2.72%	4.73%	3.13%	25.54%	29.43%	55.52%	30.13%	2.31%	5.10%
ROV Mechanical Problems	0.00%	0.00%	8.00%	0.00%	0.00%	0.00%	13.50%	0.00%	16.63%	11.17%	0.00%	0.00%
Change Orders	12.54%	9.04%	3.00%	3.24%	1.98%	6.76%	58.44%	21.30%	32.98%	9.13%	1.17%	4.16%
Approvals Delay	0.00%	13.23%	0.00%	5.44%	0.00%	18.20%	0.00%	26.30%	0.00%	22.00%	0.00%	3.00%
Steel Prices Increase	32.18%	25.50%	3.68%	3.54%	3.69%	2.43%	1.32%	1.57%	0.91%	1.43%	0.03%	0.08%
Non-availability In Local Markets	62.17%	7.00%	17.29%	39.06%	14.56%	3.56%	63.89%	45.45%	59.59%	13.04%	0.50%	1.97%
Customs Procedures	0.90%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Coating Factory Occupancy	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	18.76%	0.00%	0.00%
Material List Incompleteness	5.09%	1.54%	0.87%	0.80%	0.48%	3.29%	68.64%	18.33%	6.68%	6.32%	0.35%	0.59%
WDT (Weather Down Time)	0.87%	2.01%	3.79%	18.89%	0.23%	2.35%	30.65%	17.20%	26.70%	32.10%	0.42%	0.02%
MDT (Mechanical Down Time)	0.00%	1.15%	0.00%	13.80%	0.00%	4.01%	0.00%	16.18%	0.00%	36.42%	0.00%	0.90%
Sealine Leaks	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.20%	6.90%	0.40%	0.56%
Personnel Permits	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.87%	0.00%	2.45%	0.00%	1.64%

Table (2): Risks impact/activity “moderate”

Activity ♦ / Risk Factor / Impact ♦	Receiving material at fabrication yard		Surveing equipment approach		Loadout prefab. Material		Platform installation		P.L. Installation		Commissioning and startup	
	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule
Intervention Works	16.39%	8.00%	9.20%	2.45%	1.40%	1.09%	15.98%	23.30%	55.43%	30.00%	1.13%	3.20%
ROV Mechanical Problems	0.00%	0.00%	8.00%	0.00%	0.00%	0.00%	5.81%	0.00%	10.00%	2.50%	0.00%	0.00%
Change Orders	10.00%	6.25%	2.00%	3.00%	1.00%	6.00%	50.00%	11.50%	30.00%	8.25%	0.59%	2.60%
Approvals Delay	0.00%	12.30%	0.00%	3.40%	0.00%	12.45%	0.00%	25.00%	0.00%	20.00%	0.00%	1.00%
Steel Prices Increase	25.00%	17.00%	2.00%	2.00%	3.40%	2.10%	1.20%	1.40%	0.90%	0.72%	0.01%	0.03%
Non-availability In Local Markets	35.00%	5.00%	7.00%	30.00%	12.00%	0.80%	41.23%	16.20%	36.87%	9.32%	0.02%	0.01%
Customs Procedures	0.03%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Coating Factory Occupancy	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.30%	13.40%	0.00%	0.00%
Material List Incompleteness	4.35%	0.77%	0.43%	0.41%	0.38%	2.94%	66.87%	16.67%	5.88%	5.26%	0.27%	0.46%
WDT (Weather Down Time)	0.50%	1.94%	3.64%	18.75%	0.16%	2.22%	27.27%	15.38%	24.49%	31.58%	0.30%	0.02%
MDT (Mechanical Down Time)	0.00%	1.11%	0.00%	12.50%	0.00%	3.89%	0.00%	11.54%	0.00%	23.68%	0.00%	0.12%
Sealine Leaks	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.31%	5.26%	0.02%	0.03%
Personnel Permits	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.45%	0.00%	2.23%	0.00%	1.60%

Table (3): Risks impact/activity "Low"

Activity ♦	Receiving material at fabrication yard		Surveing equipment approach		Loadout prefab. Material		Platform installation		P.L. Installation		Commissioning and startup	
Risk Factor / Impact ♦	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule	Cost	Schedule
Intervention Works	18.84%	9.25%	24.15%	2.97%	8.07%	5.17%	28.74%	32.44%	57.03%	31.00%	2.69%	7.50%
ROV Mechanical Problems	0.00%	0.00%	13.24%	1.20%	0.00%	0.00%	14.98%	1.03%	18.73%	11.23%	0.00%	0.00%
Change Orders	13.02%	11.20%	3.20%	4.22%	2.04%	7.33%	62.12%	22.15%	34.91%	10.07%	2.34%	6.72%
Approvals Delay	0.00%	13.57%	0.00%	5.01%	0.00%	20.37%	0.00%	28.93%	0.00%	2.75%	0.00%	3.40%
Steel Prices Increase	38.10%	26.18%	4.21%	3.92%	5.08%	3.63%	1.83%	2.17%	1.10%	1.96%	1.02%	0.43%
Non-availability In Local Markets	64.16%	8.08%	18.37%	40.20%	15.62%	4.42%	71.90%	52.30%	66.17%	16.06%	1.20%	2.45%
Customs Procedures	2.30%	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Coating Factory Occupancy	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	22.10%	0.00%	0.00%
Material List Incompleteness	7.62%	2.23%	1.07%	2.83%	0.94%	3.82%	71.03%	22.29%	7.14%	6.90%	1.50%	1.20%
WDT (Weather Down Time)	1.70%	2.30%	4.46%	21.29%	1.40%	3.50%	32.87%	20.93%	26.98%	33.40%	1.84%	0.52%
MDT (Mechanical Down Time)	0.00%	2.38%	0.00%	14.93%	0.00%	5.68%	0.00%	17.28%	0.00%	38.79%	0.00%	1.68%
Sealine Leaks	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.46%	7.12%	0.00%	0.00%
Personnel Permits	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.43%	0.00%	3.19%	0.00%	2.58%

Table (4): Risks impact / activity "High"

The previous tables: (2, 3 and 4) are showing the impact of the chosen risk factors on each activity in three scenarios: the moderate which is the case that engineers are usually planning according to it; the low is the optimistic case as the risk factors have the minimum probability to happen assuming that they will happen for the game purposes; and finally the high, which is the pessimistic case. These tables and the data included, as mentioned above, are based on the historical database from petroleum company's offshore projects in order to reflect reality. However, when the data was interpreted before using in the equations the results were not mathematically logical and some errors seem to be occurred during gathering the data, may be due to human error. It can be noticed if we checked out some of the data through the three tables that some of the given figures need to be revised such as: in table (4) for instance the impact of the mechanical problems of the Remotely Operated Vehicles "ROV" surveying equipment has a greater impact on pipeline and platform installation activities than Surveying equipment approach, which is the surveying activity. Additionally, ROV mechanical problems risk has an impact on the schedule of the surveying activity by 1.2%, but has an impact on the pipeline installation activity of about 11.3%. Although the company's database has to be reliable and trustworthy, the figures needed a logic explanation that was not found there. Moreover, when applying mathematical models on the given tables before building the game it was found that all the results were losses all the time, which is not true even for the company's engineers themselves. Consequently, a theoretical correction factor "0.2" was used to avoid the error in the data results.

Another questionnaire was performed in a meeting with the experienced field engineers to discuss and gather the possible prevention and mitigation actions that could be considered based on their field experience. The table (1) in Appendix (B) represents the gathered information. From that table, the impact of the responsive measures is shown as a percentage that reduces the risk impact.

3. *Risk probability and impact on time and cost*

Some other tables, similar to the next shown table (5), were generated and the correction factor was used for each risk factor in a separate spreadsheet in order to develop the models required for the tool.

			(Optimistic)			(Most likely)			(Pessimistic)		
			Prob.	Time	Cost	Prob.	Time	Cost	Prob.	Time	Cost
Receiving material at fabrication yard	1	Intervention works	22.00%	8.00%	16.39%	58.00%	8.03%	18.52%	40.00%	9.25%	18.84%
	2	ROV mechanical problems	21.00%	0.00%	0.00%	39.00%	0.00%	0.00%	30.00%	0.00%	0.00%
	3	Change orders	7.00%	6.25%	10.00%	57.00%	9.04%	12.54%	53.33%	11.20%	13.02%
	4	Approvals delay	32.00%	12.30%	0.00%	48.00%	13.23%	0.00%	33.33%	13.57%	0.00%
	5	Market conditions	27.00%	17.00%	25.00%	43.00%	25.50%	32.18%	36.67%	26.18%	38.10%
	6	Non-availability in local markets	20.00%	5.00%	35.00%	50.00%	7.00%	62.17%	40.00%	8.08%	64.16%
	7	Customs procedures	15.00%	0.10%	0.03%	52.00%	0.16%	0.90%	18.33%	1.00%	2.30%
	8	Coating factory occupancy	20.00%	0.00%	0.00%	45.00%	0.00%	0.00%	40.00%	0.00%	0.00%
	9	Material list incompleteness	17.00%	0.77%	4.35%	53.33%	1.54%	5.09%	45.00%	2.23%	7.62%
	10	WDT (Weather down time)	21.00%	1.94%	0.50%	45.00%	2.01%	0.87%	40.00%	2.30%	1.70%
	11	MDT (Mechanical down time)	10.00%	1.11%	0.00%	51.00%	1.15%	0.00%	26.67%	2.38%	0.00%
	12	Leaks	18.00%	0.00%	0.00%	49.00%	0.00%	0.00%	36.67%	0.00%	0.00%
	13	Personnel permits	29.00%	0.00%	0.00%	40.00%	0.00%	0.00%	33.33%	0.00%	0.00%

Table (5) Probability /impact percenatges /activity on the excel sheet

From the previous table (5), risk factors have different impact and different severity as well for every activity, depends on the activity itself and the risk type. For instance, from the table one can notice that the risk called "ROV mechanical problems" has zero impact on both time and cost on the activity

"Receiving material at fabrication yard" which is logic that surveying equipment mechanical problems cannot impact or affect the work on the fabrication yard.

C. Model Scenario and equations

1. The model scenario

A model-based approach using mathematical models is used to develop the educational tool "RIG" with a user-friendly interface. In RIG tool, the user is representing the project manager "PM" of the project and he/she is responsible for finishing the project within the given budget after submitting or determining the amount of "contingency". Noticing that, for coding purposes, it was assumed that the contingency required from the user to submit should include the desired profit amount that the user wishes to gain from this project. Moreover, the contingency amount should include the amount of money needed to cover the impact of unforeseen site conditions. Hence, in the RIG, the contingency amount is representing the amount of what is called in usual practice the "markup" value. During the construction phase, the user faces randomly some of the thirteen risk factors embedded in the game. The programming language used to develop this game, as mentioned earlier, is "Flash Script" with a main goal of simplifying the interface and the output for both the student and the instructor. Therefore, the output of RIG tool can be taken to a spreadsheet for analysis for every user.

Promoting self-learning is one of the desired objectives of RIG tool. Therefore, as shown in figure (2) the flow chart of the RIG tool, a narrative part before starting the game exists telling the user the needed information to first recognize the purpose of the tool, get some information about the project while trying to answer most of the questions that the user may ask about the RIG tool regarding the project and the conditions that may cause some risks. In addition to that, the table of the associated risks, the actions that could be decided to prevent or mitigate those risks and their impact on both cost and schedule of the project is accessible to the student before he/she decides the contingency amount that will be added to the project cost.

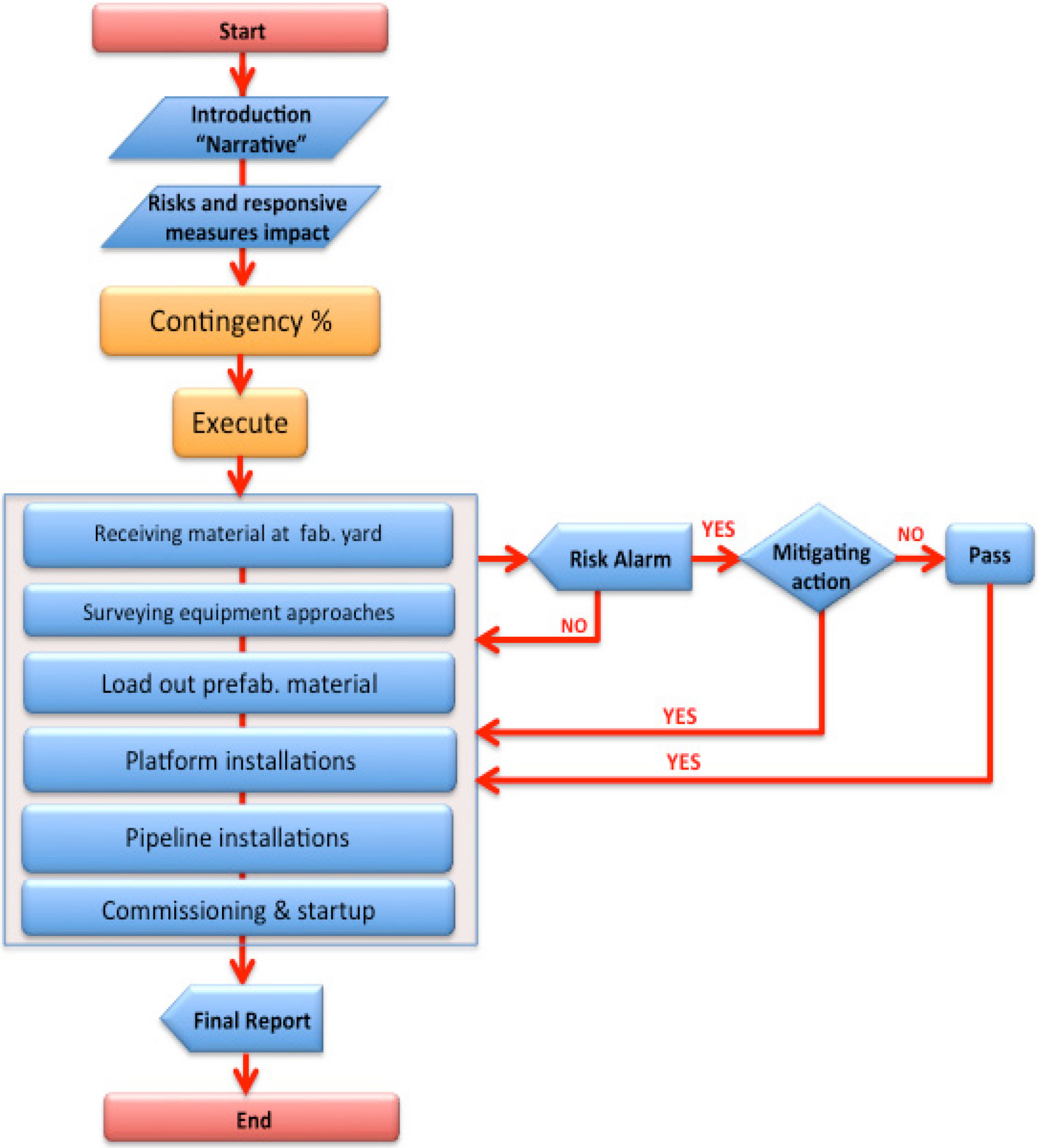


Figure (3) RIG flowchart

In this manner, the user should be able to identify the risks associated with the project and given their possible time and cost impact in terms of negative impact on project duration and budget he/she can decide the percentage of contingency to be added to the project's total cost. Noticing that, for smoothing the progress of the coding process, this percentage would include the profit margin and cover uncertainties as well. What should be considered is that the owner does not want the project cost to exceed the planned budget under any circumstances as explained in the narrative introductory screens. After that, the user identifies a shown list of preventative actions that could be neutralized, noticing that each preventative action is associated with a certain cost that is deducted from the contingency amount decided earlier. Just then, the project execution can be started and the random occurrence of risks is started. The number of the risks appearing to the user during RIG can be controlled by the instructor from an exterior file by changing one number. The exterior file contains a certain number of the probability "p" of which the random choice of the risks will start from. For example: for p is 60 the random choice will start to choose risks that have probability of occurrence equals to 60 or more.

Decisions that the student has to consider are:

1. Assign a contingency amount that will be fixed throughout the game (could be more or less than the sum of the costs of the preventative actions);

2. Select from the preventative actions which risks to prevent. Knowing that, each preventative action has a certain cost deducts from the contingency.
3. After the game starts, mitigating measures have to be considered to manage risks occurred.

Noticing that, the user's decisions can't be undone simulating real life decisions.

An example of Risk Mitigation measure:

The owner may not be able to pay the invoice in time as agreed, thus the user is allowed to take a loan from the bank with an interest rate of (8%). The interest rate is deducted from the contingency similar to all the mitigating actions. Then, the user can pay back the loan as soon as the owner pays the invoice. Noticing that, timing is essence for number of repetitions of this risk and number of times that the interest rate will be deducted from the contingency amount.

2. *The model equations*

The database results were set in the form of three matrices (i * j), where "i" is the activity number for six activities and "j" the risk impact for thirteen risk factors. The three matrices represent the possible scenarios of risk impact on the project activities in, Moderate, Low and High modes as shown in tables (2, 3 and 4).

In order to get all the possible results that should meet all the user's decisions, which vary as expected from one user to another, the probability curves were generated depending on the questionnaire results as shown in figure (3). The beta distribution is assumed to be used in probability curves for many reasons: First, the CPM method usually follows beta distribution; Second, beta distribution is usually used for research purposes in case of researcher expects that the given figures for probability are not the exact expected one, they could be either higher or lower than the given.

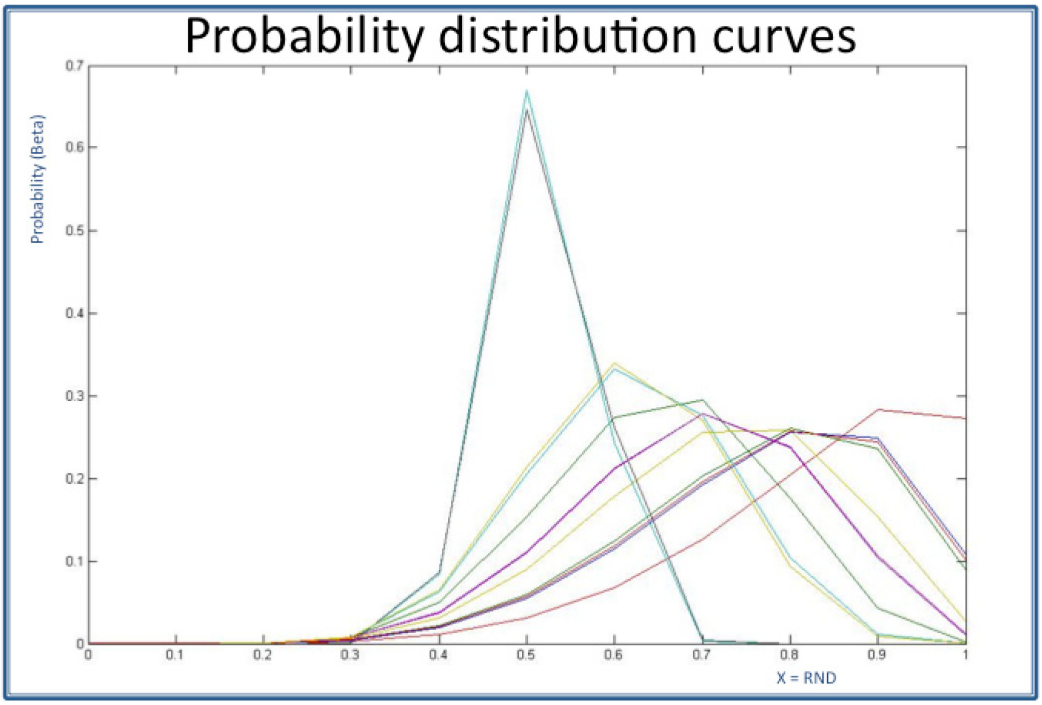


Figure (4) Probability distribution beta curves

From figure (4), a uniform random number is used to get the set of risk factors of which the user may face during the RIG. Then, from the chosen set of risk factors, all risks that have probability percentage more than p% are the risks that will appear to the user during the game. The probability percentage p%

can be controlled by the instructor from an external file in order to get different modes for the game, in addition to increase or decrease the number of risks that appears to the user during the project execution.

In figure (5) the graph is to clarify the probability curve for the risk called "Intervention works" as an example:

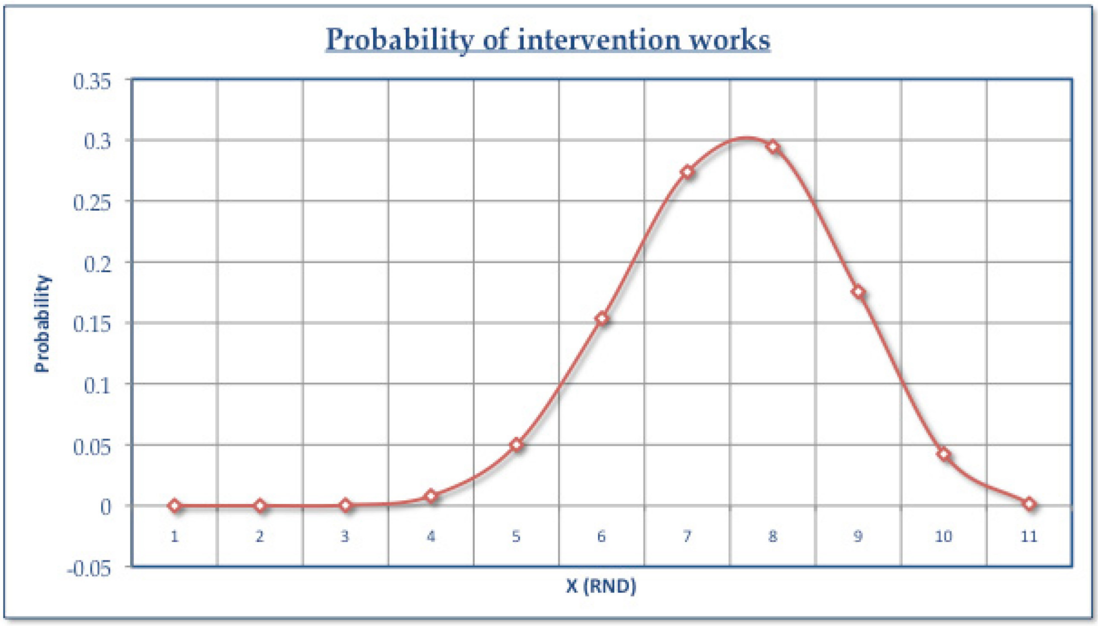


Figure (5) Probability curve for "Intervention Works" risk factor

The Beta function is used similar to what introduced by Leonhard Euler (Digital library 2012) as follows:

$$B(\alpha,\beta)=\int_0^1 u^{\alpha-1}(1-u)^{\beta-1}\,du;\alpha\rangle 0,\beta\rangle 0 \qquad (1)$$

$$Beta(\alpha,\beta)=\frac{\Gamma(\alpha)*\Gamma(\beta)}{\Gamma(\alpha+\beta)}, \qquad (2)$$

Where the derived parameters are:

$$Mean = \frac{(Max + 4\,\mathrm{mod} + Min)}{6}, \quad (3)$$

$$StdDev = \frac{(Max - Min)}{6}, \quad (4)$$

$$\alpha = \left\lfloor \frac{(Mean - Min)}{(Max - Min)} * \frac{(Mean - Min) * (Max - Mean)}{StdDev^2} - 1 \right\rfloor, \quad (5)$$

$$\beta = \frac{(Max - Mean)}{(Mean - Min)} * \alpha, \quad (6)$$

By using Excel functions for calculating and drawing the main curves: BETADIST (x, α, β, A, B), following the previous equations, gives the probability for point x knowing both α and β parameters and the A, B boundaries were estimated to be 0, 100 respectively.

As explained earlier, a random number is generated and the random probability is the outcome from the beta curve. The risk factors that have probability of more than the certain controlled percentage by the instructor are the risk factors that appear to the player randomly. A uniform distribution for the random number is chosen for simplification. The randomness purpose in the game is to ensure the variety and excitement for the users since the risk factor choice and its impact is not predictable similar to reality in projects.

In order to get the impact of the chosen risk factor, either impact on time or on cost, a triangle curve is used to represent the data presented in the previously shown tables (2, 3 and 4) for risks impact gathered information after correction in order to combine the results of the three modes of moderate, low and high respectively. The triangle curve gives two impact points, but that was ignored for simplification in programming and only one point is usually chosen each time. The next graph shown in figure (5) is an example for discussion of the triangle curve presenting the "Intervention works" risk factor impact on cost versus probability percentages.

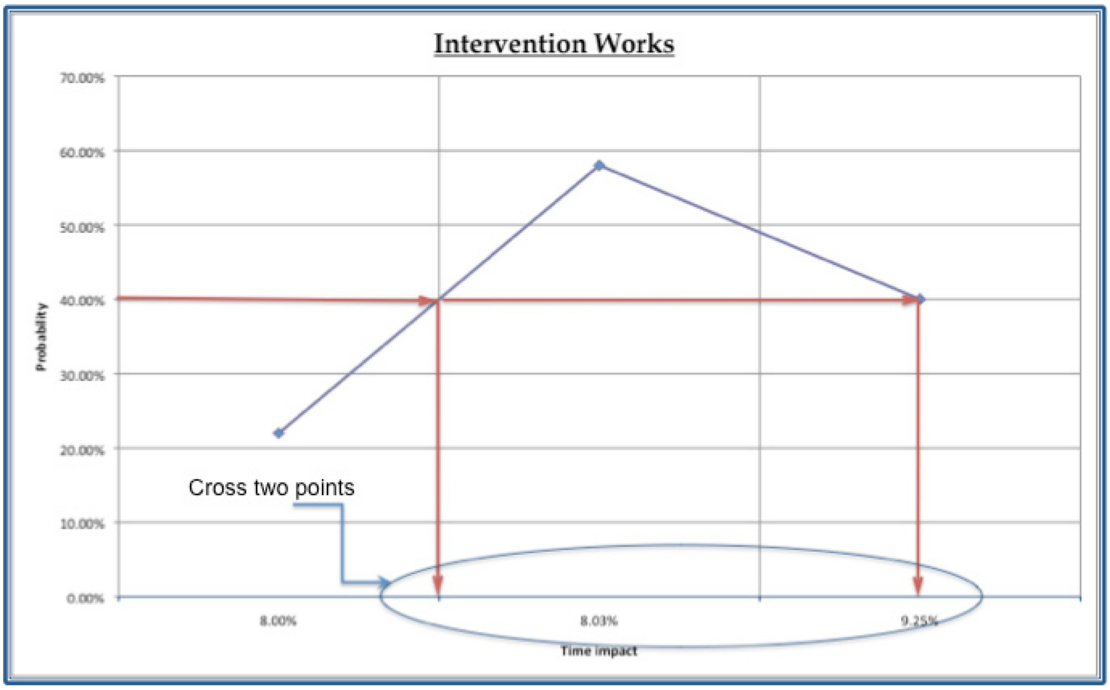


Figure (6) Triangle impact curve for risk factor "Intervention Works"

From the previous figure (5), the RIG programming can extract the risk impact that is needed to continue playing. The three points on the triangle curve are representing the optimistic, moderate and pessimistic scenarios that were gathered, as clarified earlier, from historical data of similar offshore petroleum projects from the same company. Considering that, the moderate scenario should be the optimum scenario that is usually used in planning the project strategy, which has the higher probability percentage and the lower percentage is usually the pessimistic scenario.

Noticing that, from that triangle curve one may get two different results of which can be used in future updating of the game in creating another level of difficulty, or different result for the same given probability as challenging scheme since there are two different impacts for each risk factor in this assumption. In case of using the two different impact percentages as a challenging level, it could have considered as reinforcement to the uncertainty and realistic in the model. However, this was challenging in the programming process and requiring more time from the programmer and that is the reason for suggesting that for the future work or future update if there will be any.

In programming the model itself, some equations were used in order to get the results as realistic as it could be as follows:

1. In order to determine the customized budget after choosing the prevention actions, the following equation is used:

$$PR_{j=1-n} = \sum_{i=1}^{6} (r_{ij}\% * (1 - \Pr_j\%)) * C_i, \qquad (7)$$

; Where:

i = activity number for six activities ,

j = risk factor number,

n = number of risks the player chooses to prevent,

r_{ij}=Risk impact on cost for activity i,

PR_j= Prevention action total cost,

Pr_j= Prevention action cost impact for risk j,

C_i= Activity i cost.

2. Similarly, the equation that is used to calculate the prevention actions impact on project schedule is as follows:

$$PT_{j=1-n} = \sum_{i=1}^{6} (t_{ij}\% * (1 - Pt_j\%)) * T_i, \qquad (8)$$

Where:

i = activity number for six activities ,

j = risk factor number,

n = number of risks the player chooses to prevent,

Risk impact on time for activity i = t_{ij},

Prevention action total duration = PT_j,

Prevention action time impact for risk j = Pt_j,

Activity i duration = T_i

3. The risk impact on contingency are based on some equations that were generated in the game coding as follows:

3.1 First: in case of taking a mitigating action:

$$R_{ij} = r_{ij}\% * C_i, \tag{9}$$

$$MR_j = (r_{ij}\%(1 - Mr_{j\%})) * C_i, \tag{10}$$

$$MR_{j=1-n} = \sum_{i=1}^{6} (r_{ij}\% * (1 - \text{Pr}_j\%)) * C_i, \tag{11}$$

$$PT_{j=1-n} = \sum_{i=1}^{6} (t_{ij}\% * (1 - Pt_j\%)) * T_i, \tag{12}$$

3.2 Second: in case of no action is taken (pass):

$$R_i = \sum_{i=1}^{6} r_{ij} * C_i, \tag{13}$$

$$T_i = \sum_{i=1}^{6} t_{ij} * D_i, \tag{14}$$

; Where:

i = activity number for six activities ,

j = risk factor number,

n = number of risks occurred,

r_{ij}= Risk impact on cost,

t_{ij}= Risk impact on duration.

4. The interest rate of the loan that the Project manager needs to continue playing the game:

$$D = IR + L, \quad (15)$$

$$IR = 8\% * L * (\frac{Y}{12}), \quad (16)$$

; Where:

L = the principal loan

IR = interest value

D = total debt due

CHAPTER FOUR:

MODEL IMPLEMENTATION

A. Introduction

In this chapter, the developed RIG tool is described step by step. Each screen of the game is considered a new step to be explained and how the user is playing it. A light is going to be shed on the anticipated outcome of each part of the RIG tool as well. Noticing that the programming language used is the "Flash Script" because it is simpler than other programming platforms in developing games and to add some simple animation tools, videos while interacting with the player with the privilege of using through web pages.

B. Step 1: Narrative part

An introduction narrative screen appears for the player after he/ she writes his/ her name. The purpose of the narrative screen is to introduce the player, as the project manager, to the game and how to play it. In this narrative part, the owner tells the player what he/she is requested to do exactly, in addition to the basic information about the project description. Moreover, the user can visualize the project's unforeseen conditions from this part clarifying some feature problems occurred in previous projects that were installed in similar circumstances. Some of the useful information presented for the user before submitting the contingency value is: economical situation of the country, the proposed site condition and the expected weather. Noticing that, the text included in the narrative screen can be easily modified any time by the instructor from an exterior file in order to add or remove any information as considered necessary.

The narrative screen explaining the project scope:

Figure (7) Narrative screen

C. Step 2: The player's first decision

The player has to decide the best offer that covers any possible risks and guarantees a rewarding profit margin through submitting a value called "contingency" representing a percentage of the total budget. Considering that, the user as the project manager has the opportunity to explore the table, which is inserted in the same screen summarizing the most associated risk factors along with the suggested preventive and mitigating actions. The impact of each action, for the thirteen risk factors, is provided in that table for the user as guidance showing the percentage decreasing the risk impact if happened in order to be able to assign a contingency amount that could be more or less than the sum of the costs of these actions. Noticing that, timing of the risks occurrence is a very important issue as well that may cause a higher damage than expected. The contingency percentage amount is the first decision for the user to take in RIG tool and decisions cannot be undone simulating real life decisions.

The anticipated outcome from this step is that the user could learn the basis of submitting an offer and risk identification. Simultaneously, this part of the game provides enthusiasm among users stemming from the competition in submitting the best offer, and hence making the learning process more interesting. Noticing that, when submitting an offer, the user should consider wining more projects with the same owner or increase his/her market share as explained in detailed in (Nassar 2002).

The contingency decision screen where the risks and responsive measures are shown:

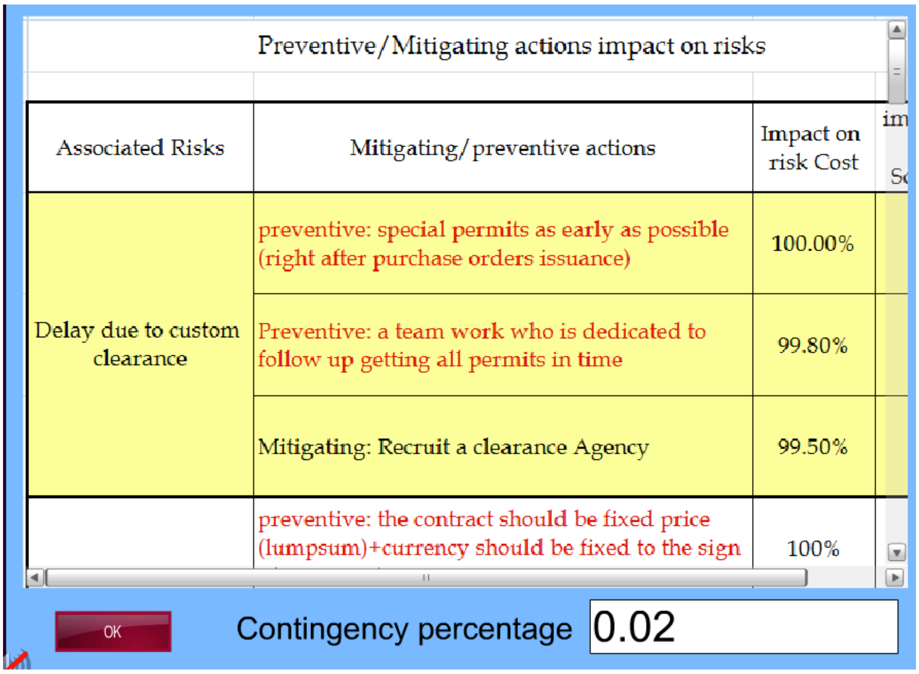


Figure (8) Contingency decision screen

D. Step three: Preventive actions

The third step, the user has to decide to prevent one or more of the possible risk factors, or he/she may choose not to prevent any of them at all. Knowing that the cost of preventing a risk is less than mitigating it during the project execution, one may consider preventing the most anticipated risks or the risks with a higher severity according to the given historical data. Therefore, the user can anticipate the possible risks that may occur from the narrative part and that is the reason why this part is important for him/her to read well at least for the first time. Noticing that, the cost of prevention actions will be deducted from the contingency amount that the user calculated and added earlier. Two counters appear on this screen showing both the project cost and the contingency amount. When the user decides to prevent any of the shown risks, the counter of the contingency amount decreases by an amount. That amount is the impact of the preventive action on the cost. When the user decides to choose a certain risk factor to prevent, another options screen asks which method of prevention to choose, which can be considered as if he is getting into a contract with another contractor to do that job for him and prevent the risk or take the risk as a third party, and such actions cannot be undone in real life projects. Therefore, similar to the contingency decision, it is not easy for the user to take back these decisions, simulating real life management decisions.

The projected outcome of this step is that the user could learn the basis of anticipating the possible risks from the historical background described in the narrative part in addition to the given table giving the actions impact on costs and schedule. Therefore, all the previously given data could give the users a clear idea about the severity of the given risks and helping them in deciding which risks to prevent.

The Preventive actions decision screen:

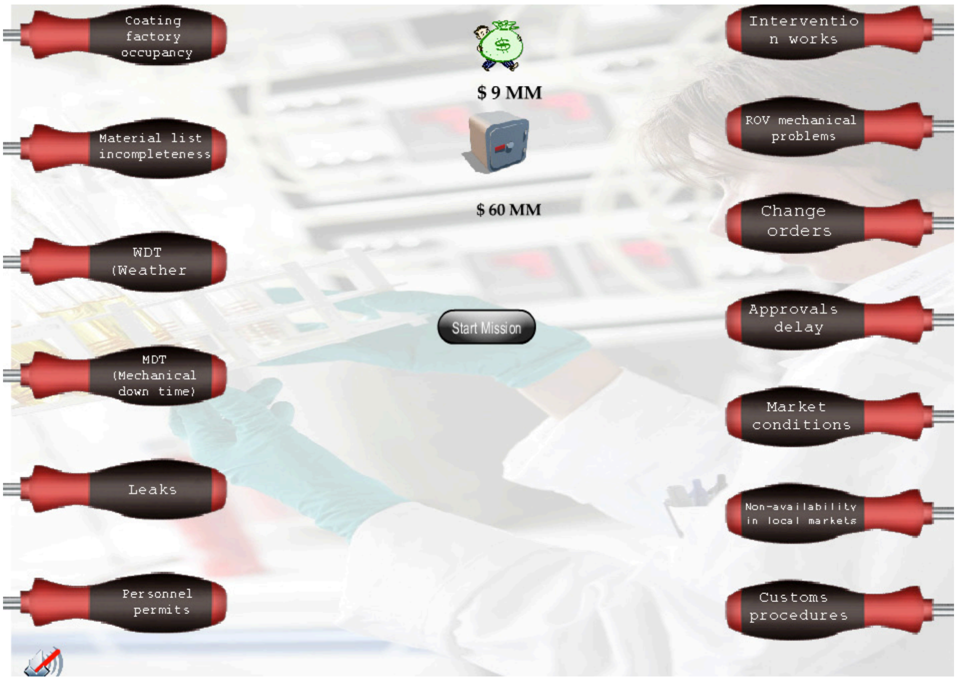


Figure (9) Preventive actions screen

As an example for preventing the risk "lack of material in local market" the user may order 20% of the required material, which will prevent this risk from occurring with additional benefit that it may prevent the risk of "incomplete material list" as well. Additionally, another prevention action that can be chosen instead of ordering the additional 20% material is investigating the availability of material in local market during engineering phase and assign special crew for following up material delivery.

E. Step four: project execution

The user can now start the project execution phase and time is stepped. During the execution, some illustrative movies are played for the user to scrutinize the offshore installations. And the original link of these movies can be seen for all of them for the user if he/she would like to check out the source. Additionally, the explanation text appears in the right side of the screen could help the user to get some information about the installations steps in the movies. Noticing that, the text are in separate files and editable for the instructor to add more information if needed. Some of the possible risk factors appear to the user randomly from the risk factors list.

When a risk happened the movie is paused and the user has to decide the best response measure from his/her point-of-view. There are two decisions, at this point: 1- the first one is to decide to take the risk, 2- the second one is to either move the risk to another party or to find a way to deal with it and minimize the impact of the risk.

The execution of the project starting:

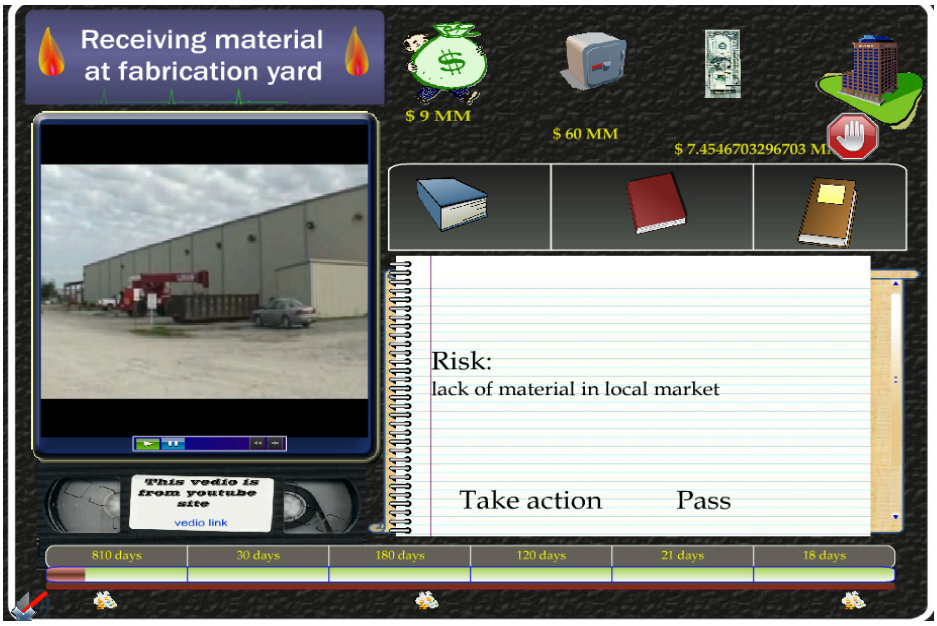


Figure (10) Project Execution and RIG main screen

During the project execution, the user is facing an additional risk factor, which is a shortage in the cash in. The cash in is the owners' payments for the user as the project manager and they should be, as stated in the narrative part, paid in four installments. The first payment is a down payment for the project to get started; the subsequent three payments are divided equally on the project execution schedule. During execution, at least one of the payments is delayed causing a major crisis of which the project is postponed since the contractors refused to work unless they are paid. Therefore, the user will have to ask for a bank loan with 8% interest rate per month as shown in figure (11).

Noticing that, the interest rate will be deducted from the "contingency" value. However, the user can pay the loan as soon as possible when he/she receives the invoices from the owner in order to minimize the interest rate. Noticing that, the first payment, which is the down payment, is always paid and committed from the owner. Accordingly, this problem only occurs in the next payments, assuming that it is uncertain that which payment that the owner will fail to pay.

A risk mitigating measure:

Figure (11) Cash flow: an example of risk mitigating measure

Noticing that, timing is essence for number of repetitions of this risk. Meaning that, the user should recognize the best time to pay back the loan to the bank so he/she does not have to repeat this risk more than one time or may be two times at most; no need to rush!

The Bank loan deal:

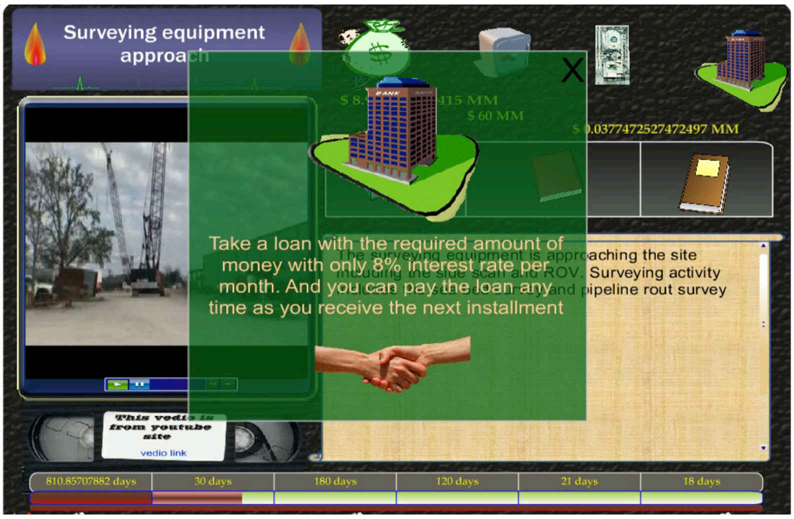


Figure (12) loan agreement with the bank

F. *Step five: End game and final report*

The final report appears at the end of the game in two forms:

The first one is as shown in figure (13) summarizing the main data of the project's duration, base cost and the base contingency that the user started the project with, in addition to the final contingency and final duration. In addition to that, the net value of variation NETVAR (Chan 2001) is calculated, which is the difference between the final contingency remaining to the project manager and the base contingency. NETVAR is to measure the project cost variation, but it is used here to measure the contingency variation since the user performance is evaluated mainly through his/her decisions, in addition to the fact that the owner from the beginning decide that the project budget should not exceed the planned under any circumstances. Therefore, the project manager is the one who is taking all the risks and committed to execute the project under that condition. The reason of using the NETVAR from the Key Performance Indicators KPI in this screen is that giving both the user and the instructor the sense of the effect of his/her decision on cost. *The final report "KPI":*

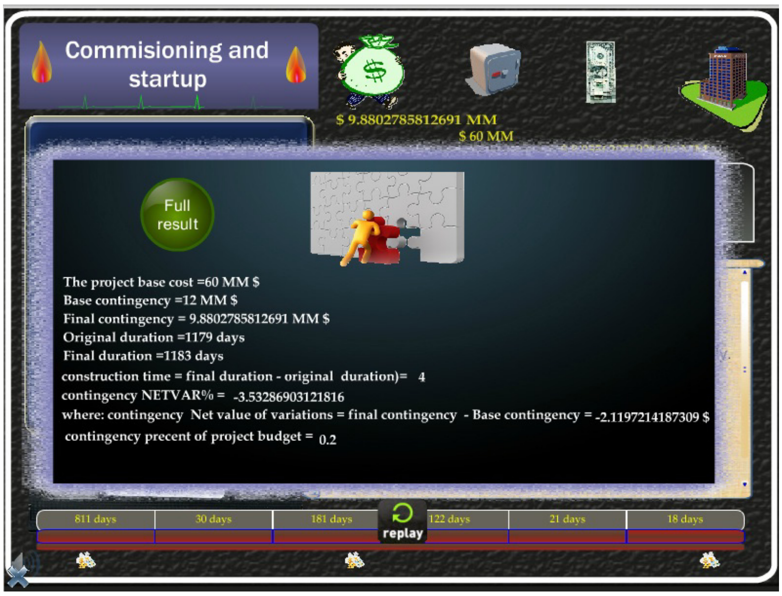


Figure (13) Summary results screen

The second results screen is as shown in figure (14) is the full detailed results of the cash-time behavior showing the different variables of the game such as, the number of preventive actions taken by the user and the number of times of paid interest rate.

The full results screen:

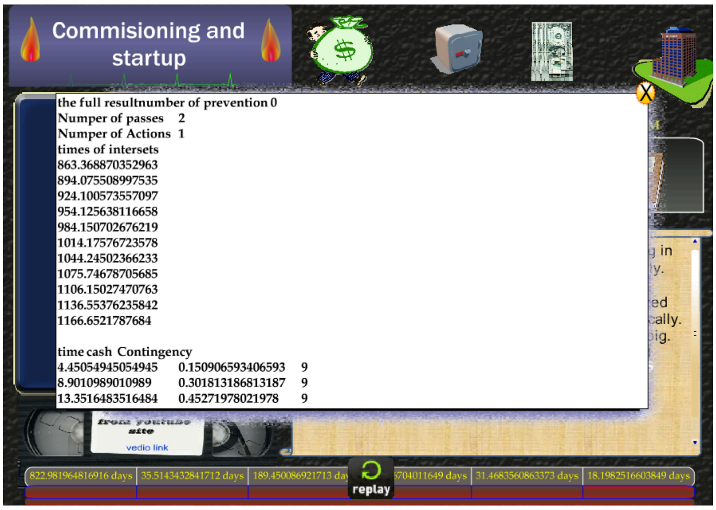


Figure (14) The Full results screen

From the final results screen, the instructor can evaluate and analyze the performance of each user along the game and compare users' decisions. In the full screen, the data that can be found includes the number of prevention actions that the user decided to take, number of mitigating actions and pass actions for risks occurred during the game, times of interest rates that were deducted for the bank loans, and finally the cash flow and contingency along the project duration or along the game. The full results data can be copied and analyzed by using spreadsheet in Microsoft Excel.

What should be mentioned is that the budgeted cost of the project is as planned as can be shown in the next figure (15).

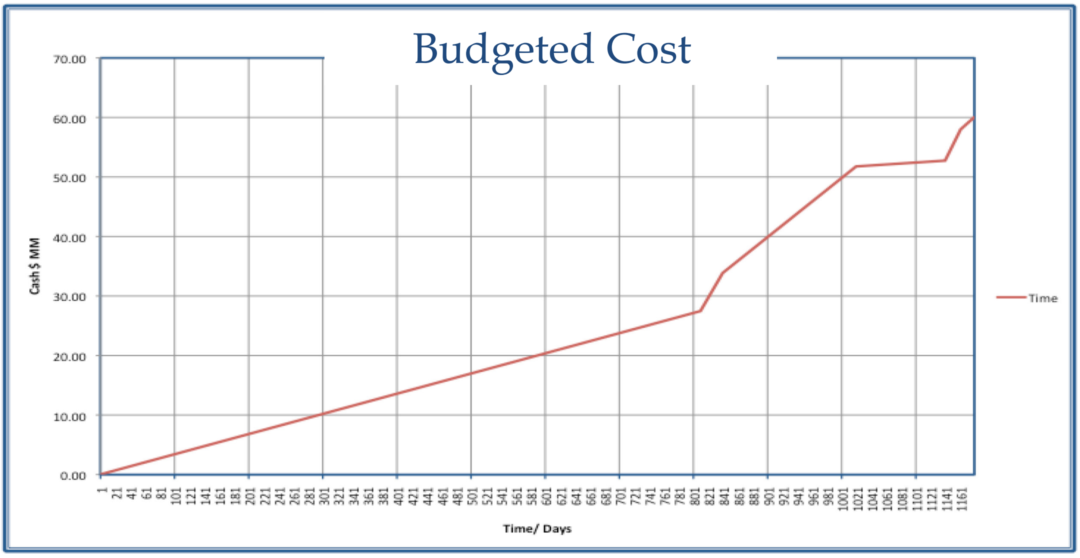


Figure (15) Budgeted cost

It was assumed that the project budget is separated from the contingency that the user decides to bid to ease the model calculations as well as the final analysis. Therefore, a chart representing the contingency versus time was suggested other than the project cash flow chart, is to analyze the user's decisions. However, to make the tool more exciting, the instructor may encourage users to use less contingency value, thus wins the bid, and meanwhile win a profit margin at the end of the tool.

CHAPTER FIVE:

EVALUATION AND ANALYSIS

The final stage of the developed RIG tool was evaluation and validation. The RIG tool was evaluated through two main methods: the first one was to program the game to run randomly for 500 iterations with random choices and random decisions; the second was evaluating the RIG tool itself by experts working in the petroleum projects field. Subsequently, using the spreadsheet, some analysis was performed to compare the two evaluation methodologies testing whether the RIG tool provided different or similar results for human decisions compared with random decisions.

A. The model validation

See Appendix (C) for a snap shot of the "500 trials full results" table.

What should be in mind now are the variables in the game's equation:

1- Contingency value that the user chooses,

2- Prevented risks that could happen during the project execution,

3- Mitigation action(s) for the risks in case of not prevented,

4- Delay of owner's payments leads to lack of cash in.

Consequently, all of the previously mentioned variables are affecting the results of the game. Noticing that, the delay of the owner's payments is one of the risks but it is special that when it happened only one response measure can be decided by the user, which is taking a loan.

1. *Simulation analysis*

First, a 500 random runs of the RIG tool was mainly aiming at two main streams: the first one is to validate the tool and examine the used equations in the model that are giving logical results; the second is to use it as a guide to compare with the user's decisions.

Some of the results are presented here for discussion as follows:

The average of the 500 simulation, maximum and minimum results:

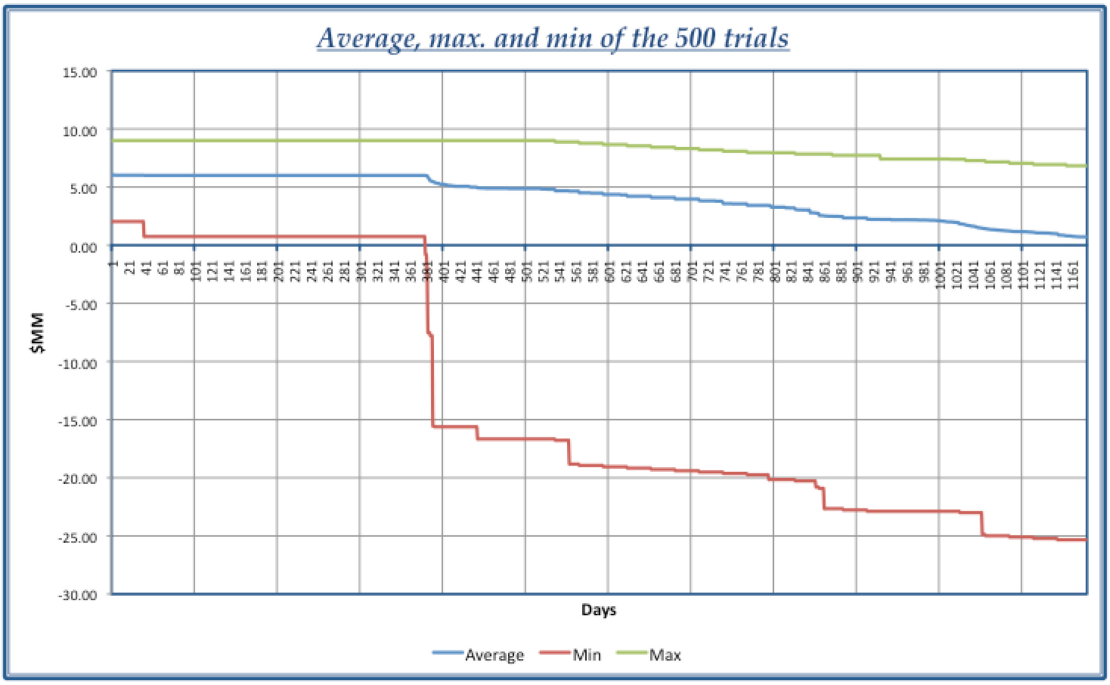


Figure (16) Average of the 500 trials

Figure (15) shows the average of the 500 trial's results along the game time with random risks occurrences and random decisions. Noticing that, some of the trials presume profits and others losses. On the same curve, the maximum and the minimum boundaries are plotted too in order to get the entire area of the possible decisions that might be located in. Noticing that, the average of the minimum curve shows losses as in sudden points, not always gradually, because of the cash flow risk happening where the owner fails to pay the invoice to the project manager in addition to the occurrence of other random risk factors. Although the cash flow risk timing should be uncertain, it seems that from the results, in most of the trials this risk happened at the first invoice, and a very few number of the results show it occurs in another invoice or infrequently never happened at all.

2. *Sensitivity analysis*

The next step was performing a sensitivity analysis for model validation. The main variables that have the major impact on the profit are the “contingency value” and which risks prevented. A 500 run was performed for contingency values from 0.03 to 0.15 and get the final profit; the increment for contingency from 0.03 to 0.15 is 0.01. In each run no prevention actions and no mitigating actions. However, the risks occur randomly as programmed. The findings of the sensitivity analysis for the contingency impact on profit were found as follows on the next figures (16) and (17):

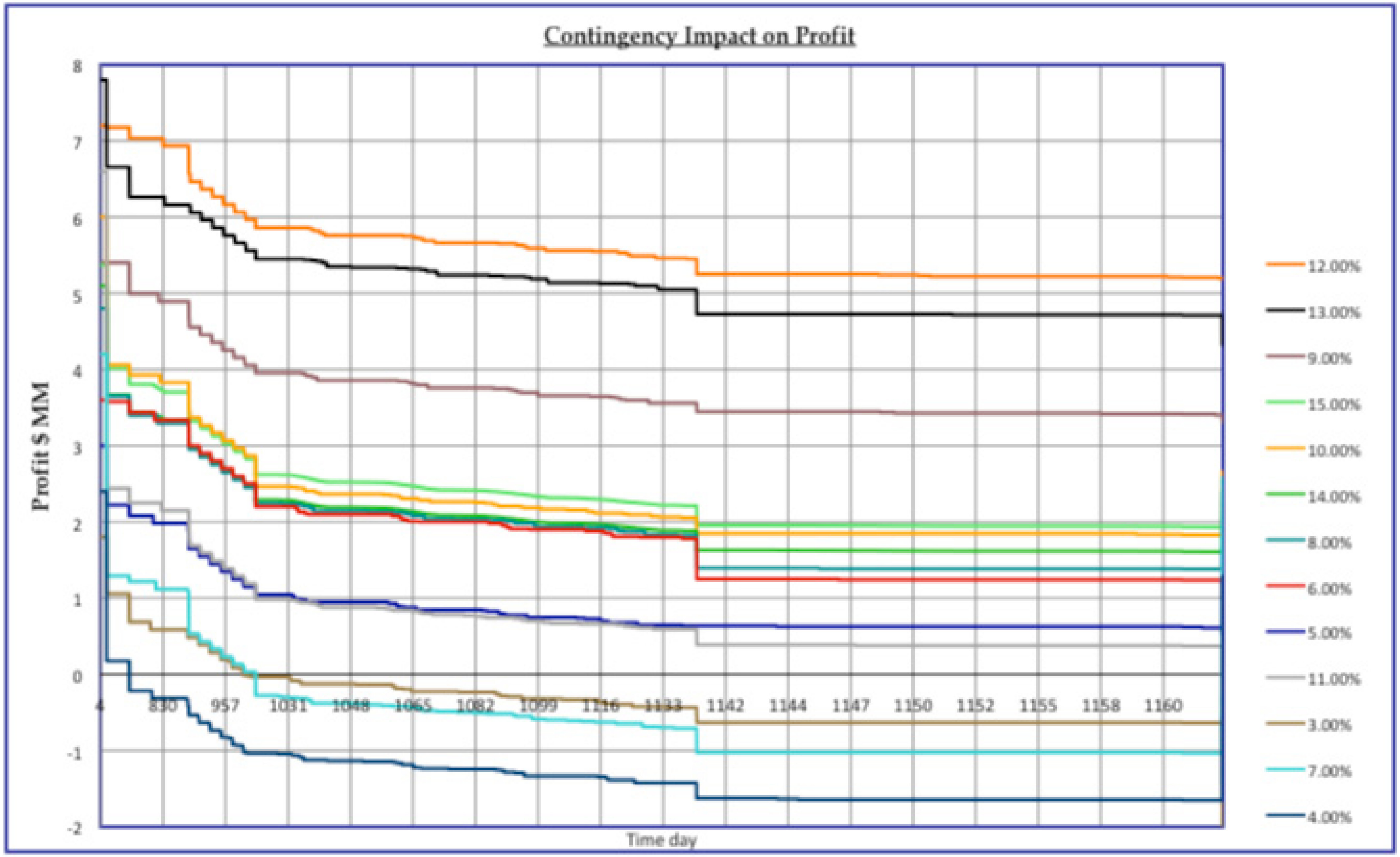


Figure (17) Contingency percentage value and profit

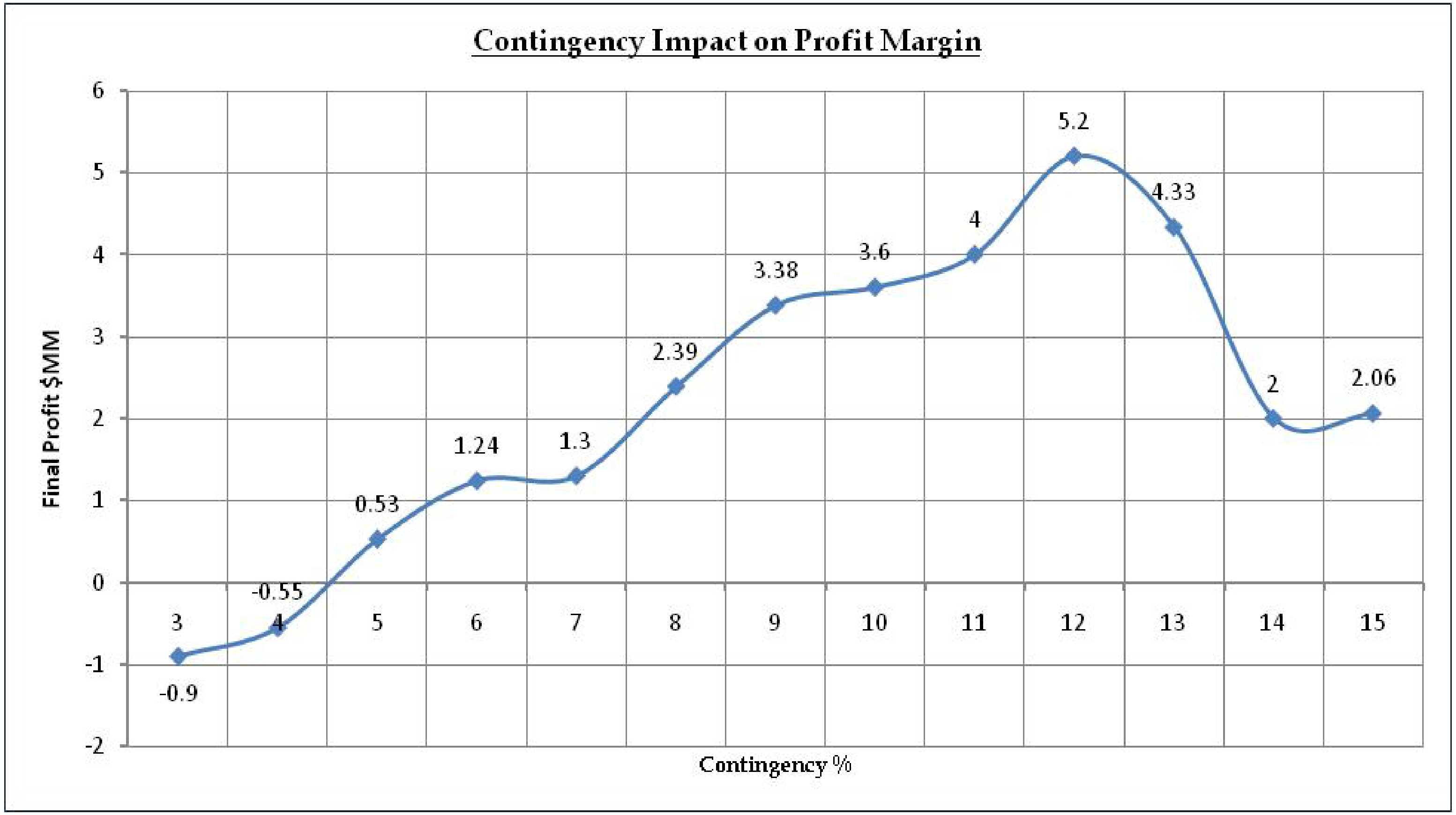


Figure (18) Contingency impact on profit margin

Figures (17) and (18) are showing the impact of contingency percentage value on the final profit; it can be concluded that:

- The higher the contingency percentage value give higher profits but to a certain limit. The meaning of that is assigning extra money by the user to account for risks is not a smart way of thinking.
- Risks occurred randomly as the model is programmed, therefore, ensuring higher profits and/or minimize losses require risk identification prior to determining the contingency percentage.
- From graph (18), the higher profit was successfully met at contingency value of 12%, but for higher contingency percentages decreases noticeably.

The previous results are leading to performing a sensitivity analysis for the next variable, which is the impact of prevention action on profit margin.

The performed analysis was performed by choosing to prevent risks from 1 to 13 and run the RIG tool for about 500 times to get the final profit. In the 500 iterations the contingency is constant and equal to 15%. The risks occur randomly as programmed.

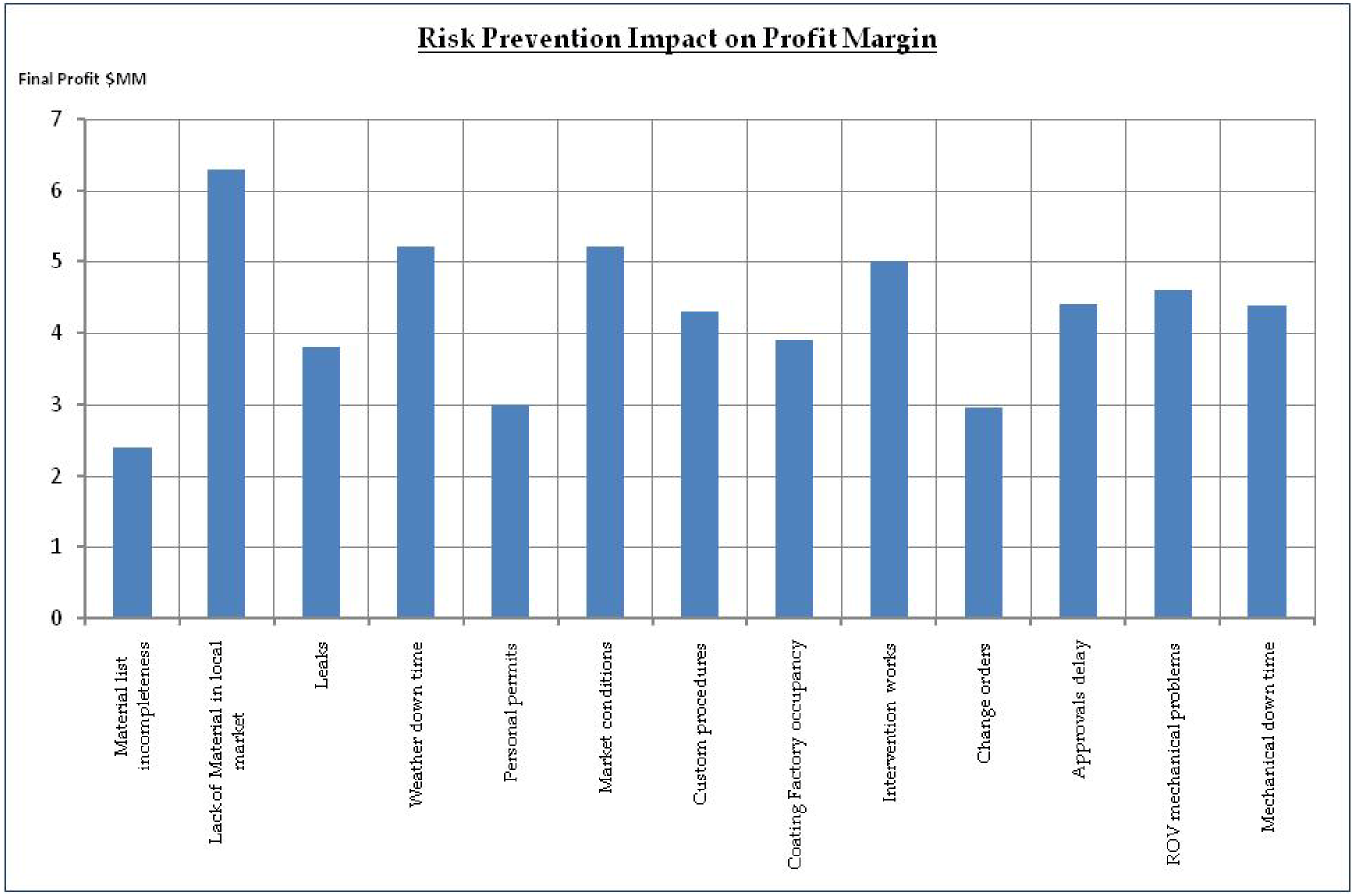


Figure (19) Preventive actions impact on profit

Figure (19) shows the impact of the risks preventions on the final profit; it can be concluded that:

- The highest profit was achieved when preventing the risk called "lack of material in local market", which may leads to the conclusion that this is the most probable risk and requires a responsive measure.
- Preventing risks in general is securing profit margin ranging in between two and six million USD in respect to the model data. Therefore, risk prevention would be beneficial and could secure enough profits at the end of the project.

Although it may not be able to be concluded from the chart, but choosing not to prevent any of the given risks does not necessarily generating losses since risk occurrence is not a must, and this may not a good choice.

B. Experts validation

A number of graduate engineers were chosen to evaluate the RIG tool. This number represents about 5% of the total number of engineers working in the petroleum company. The evaluation performed in a training lounge in the administrative building in one of the major petroleum companies. Engineers who evaluated the RIG tool have got two to five years of field experience. The final results were gathered at the end of the training session and plotted on the simulation average curve for analysis and evaluation. Questionnaire forms were filled out by the engineers after testing the RIG tool along with quick discussions regarding the effectiveness of the tool. The final results and the analysis are discussed in this part, then the questionnaire results and the engineers' evaluations.

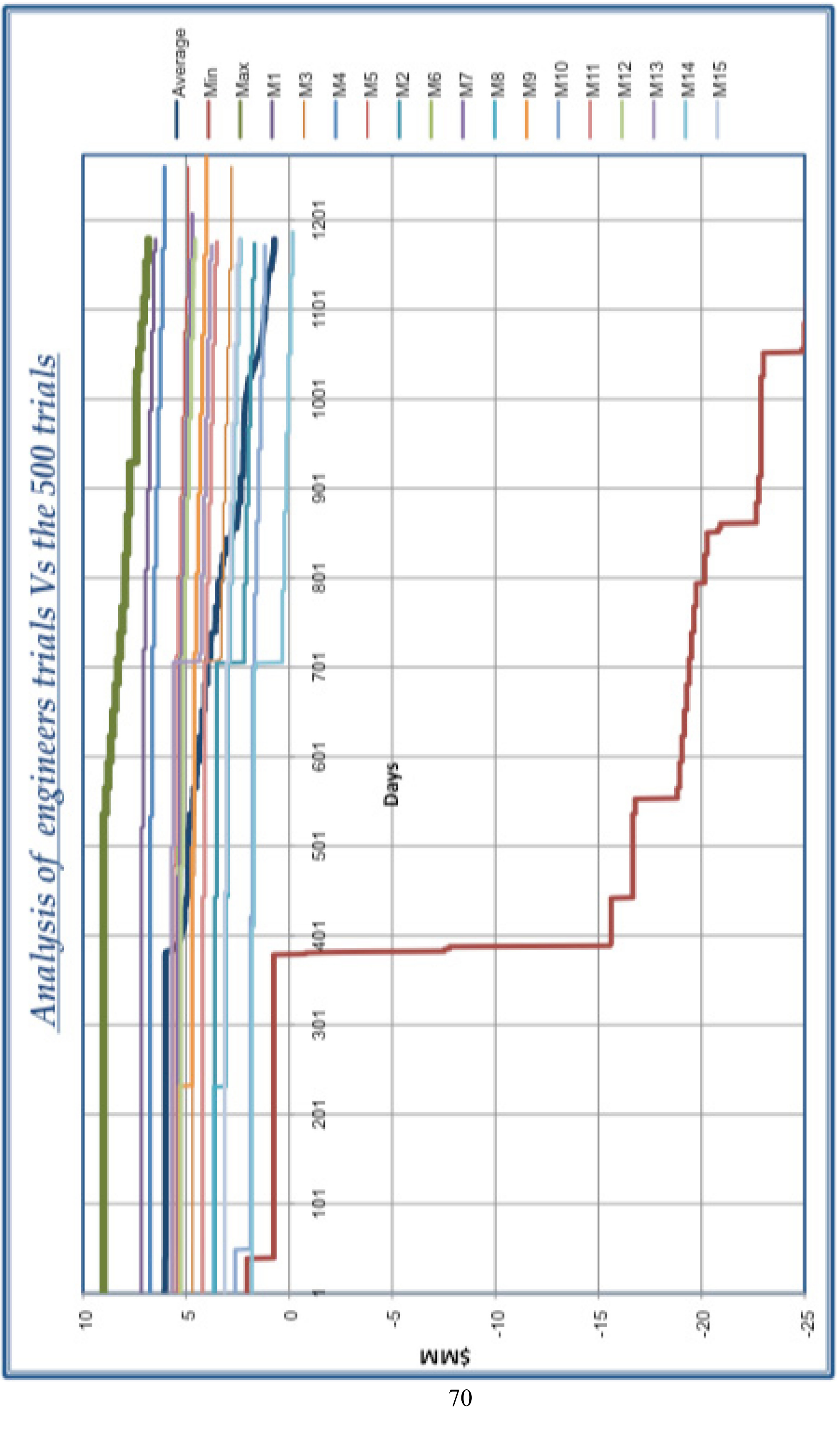


Figure (20) Analysis of experts results

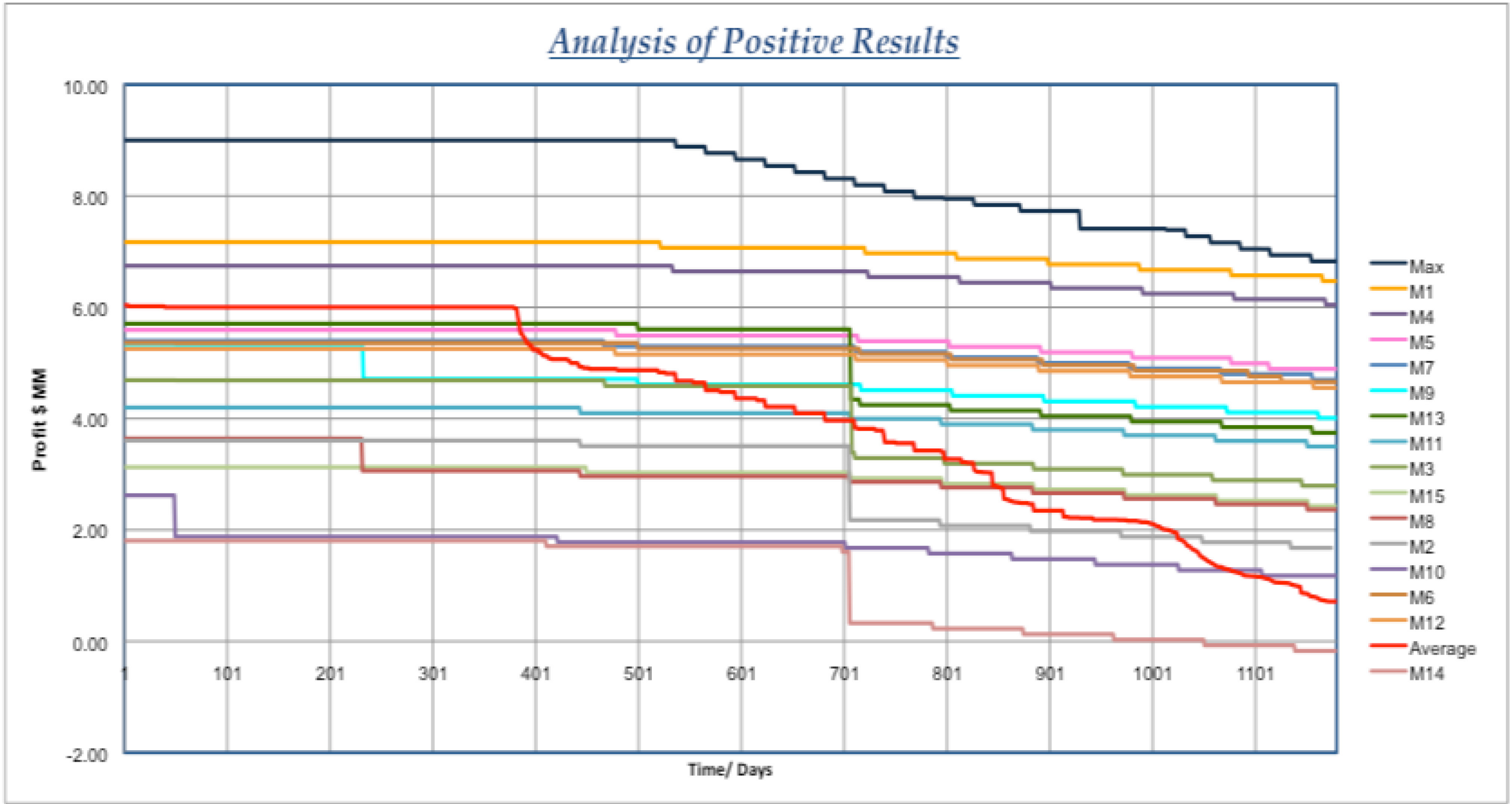


Figure (21) Analysis of experts positive results

As shown in Figures (20) and (21), the fifteen engineers' results were plotted on the same Figure (16) for the average, minimum and the maximum boundaries resulted from the 500 simulation iterations. Most of the engineers' results seemed to start with values less than the average curve, but only one of them ended the RIG with losses and has got negative results. Although engineers who evaluated the RIG have some background on risk management, only a few of them ended the project in time. Noticing that, the RIG tool does not have any direct penalty for delay in schedule, and the main losses that the user would encounter in his/her profit margin are the impact on cost.

Appendix (D) is showing some of the statistics from engineers' choices along the RIG tool and how they managed uncertainties. From these tables few players were able to anticipate some of the risks that actually occurred during the RIG tool, and hence they prevented those risks. Almost all the users did not choose to pass any of the risks; they preferred to take mitigating actions to minimize the impact of those risks as much as possible. Choices of the users are so much apart from the minimum curve of the simulation trials, which is logic since engineers were thinking while trying to maximize their profits through taking the best decision.

Finally, the questionnaire evaluation form filled by the users and they are attached in Appendix (E). To be able to analyze the results, all the questionnaire results gathered in one spreadsheet in Microsoft Excel in the table shown in table (5).

Strongly agree = "4"; Agree = "3"; Uncertain = "2"; Disagree = "1"; Strongly Disagree = "0"

RIG evaluation "The Risk management Game"

Questionnaire	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
1- The game reflects real risk problems	3	3	4	3	3	3	3	3	3	3	3	3	4	3	3
2- The game provides enjoyment	3	4	3	2	3	3	3	3	2	2	3	2	3	3	3
3- The game is assisting in risk management learning	2	4	4	3	4	4	4	3	3	3	3	3	3	3	4
4- The game time was enough	3	3	4	3	4	4	3	4	4	3	3	2	3	4	3
5- The game produces fare results reflecting the decisions you made	2	3	4	3	3	2	3	3	3	3	3	3	3	3	3
6- The game interface is clear and simple	3	4	4	3	4	4	4	4	3	3	3	2	3	4	4
7- The game promotes self learning	3	4	4	3	4	4	3	3	2	2	4	3	4	3	3
8- The game is easy to use	3	4	4	3	4	4	4	4	3	3	3	2	3	4	4

Table (6) Questionnaire results

Table (5) is used to prepare the graph shown in figure (21) showing the questionnaire results, noticing that the used methodology was a numerical scale "Likert Scale", and for "strongly disagree" up to "strongly agree" the given scale was zero to four respectively.

Analysis of the questionnaire results:

Although almost all the players agreed that the RIG tool reflects real risk problems, about 20% were neutral when they answered the question of providing enjoyment while playing the game. This is important because the RIG should be an educational tool that provides joyful environment.

However, one of the players found it funny enough to strongly support the new tool.

Most players found the RIG a successful tool that could have a contribution in training on and/or learning about risk management, and 40% were strongly supporting that idea.

By analyzing results from the next figure (22): most players found the time spent in playing the game was enough and that because it meant to be as short as possible to avoid getting bored if long or losing the purpose of learning if short. Although almost all the players agreed that the RIG tool produces fare results reflecting the decisions that the player made during the game, about 15% of the sample disagrees with that. Meaning that, about 85% of the engineers were satisfied by the results and found them logic. Noticing that, only one of them lost his profit margin and got negative results, but it seems that there were other players were not pleased with the remaining amount from the contingency as a satisfying profit margin.

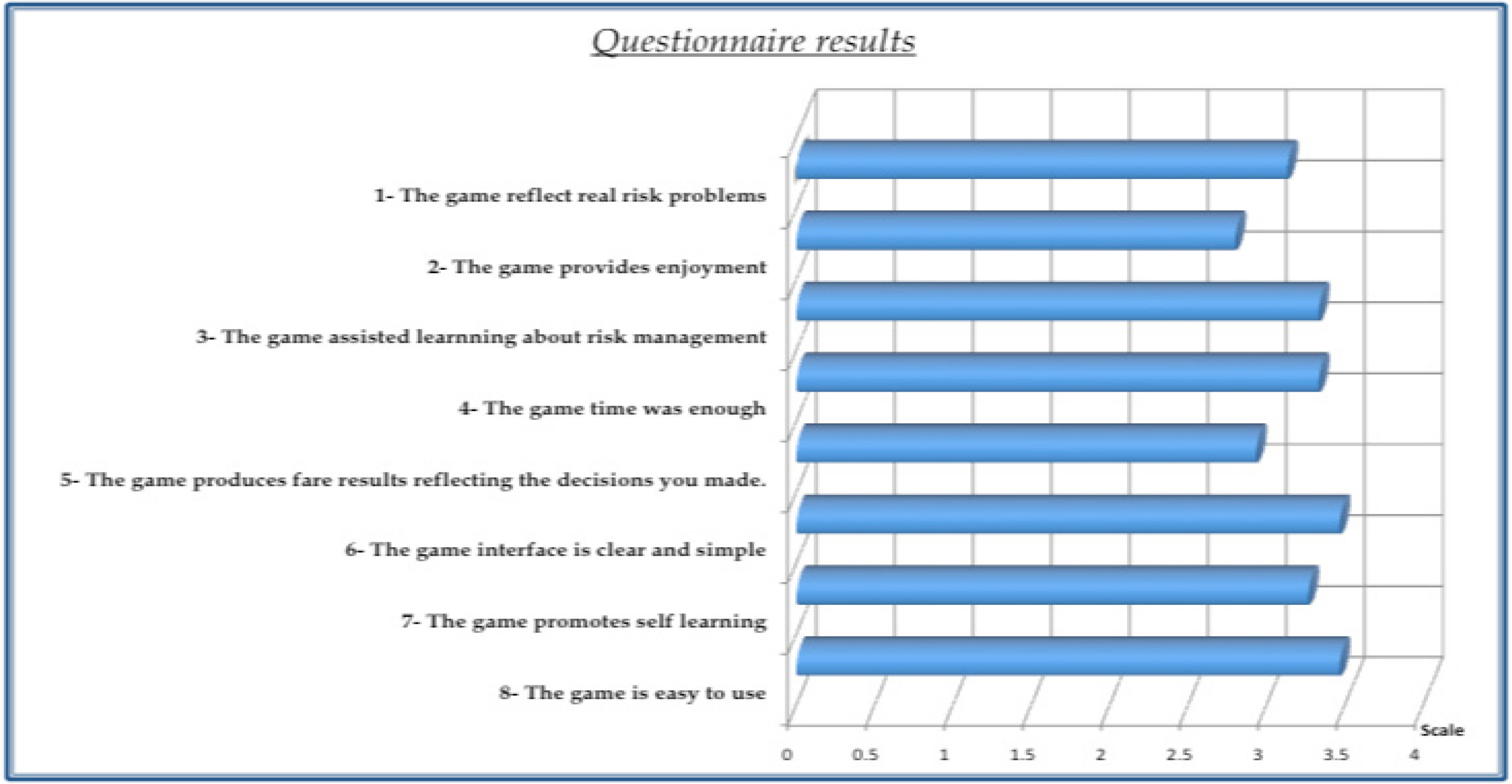


Figure (21) Questionnaire results

In fact, during the session, a few questions from some engineers had triggered regarding the RIG itself. Most of the asked questions were about: how to get a certain piece of information, what if I need to get back to the previous screen, and what if I need an expert opinion during the tool. However, in the questionnaire results about 85% satisfied and agree that RIG promotes self-learning. In addition to that, 40% of the total number strongly agrees with that, which is a very encouraging result. The interface simplicity and the visual aids in it strongly attracted more than 50% of the users, and actually almost all the users agree that the interface is clear and simple. Similarly, the RIG was found easy to use by 94% of the engineers. From Figure (22) almost all the results are above the average.

CHAPTER SIX:

SUMMARY AND CONCLUSION

A. Summary

In recent years, computer aided tools have become more useable in different areas such as project management. Simulation and educational games provide engineers with a joy-able environment, assessing self-learning, inspiring creativity and enabling safe site training.

In this research, a simulation tool "RIG" was developed for decision support system and/or training graduate engineers the basics of risk management aspects while gaining decision-making skills. The developed RIG tool is simulating a petroleum development project consisting of installation of an offshore platform and the required offshore pipeline exporting production to the onshore treatment facilities. RIG tool is training less experienced engineers on securing a profit margin while preventing or mitigating uncertainties, which requires risk identification first. Training on decision-making, promoting self-learning, providing visual and interactive learning tool, while trying to impart enthusiasm are the main objectives of developing the risk management training and educational tool. The realistic results that resulted from the tool could assist in decision-making and act as a decision support system.

Flash Script was the programming language that was used in developing the RIG tool, and a simple interactive interface implemented. The technical data was gathered from the historical database from a petroleum company working in Egypt, in addition to some interviews with experienced professional engineers working in offshore petroleum projects. After RIG was developed a 500 simulation iterations with random choices was performed in order to evaluate the model and the results was analyzed. The simulation analysis proved that if the user failed to decide the best contingency figure and identify or expect the risks that may occur in addition to prevent most of them, he probably lose a lot of money that may sometimes be exceeding the amount of contingency by 50% in some cases. A sensitivity analysis was performed as well in order to validate the model and recognize the impact of the main variables in the model on the final profit. The findings were that raising the value of contingency percentage does not necessarily give higher profits since risk management should be performed first. Additionally, risk prevention prior starting the project execution should be on the basis of risk identification and proper risk management.

Next, RIG tool was validated by some engineers with a minimum experience of two to five years in the field of petroleum sector and the results were compared by the simulation analysis. The evaluation results were found encouraging and most of the evaluators were enthusiastic to the main purpose of the RIG tool of training on uncertainties during construction phase in a safe environment. Additionally, the experts were more open to the simple interface and the simple information that were given during each activity's execution.

The RIG tool is Published on a free website and accessible for trial:

http://www.iamimmigrant.com/master/Core.swf

B. Conclusion

The developed RIG tool has succeeded to introduce a new model in risk management as well as a new methodology in training less experienced engineers with providing them by the basics in managing uncertainties in the construction phase for a petroleum project. Providing a safe environment for on-site training is one of the achieved objectives of the RIG tool for a petroleum project, which is hazardous by its nature. The decision making while experiencing reality since no decision can be undone was the overwhelming idea for the users at first, but they were adapting and enjoying using the RIG tool after that and found it very simple with no complicated tasks.

C. Future work

Some characteristics were added to RIG tool for adding more excitement, but they need to be tested in future for examining their results:

1. The instructor can control the mode of the game and make it harder or easier through controlling the number of risks that appear to the students.

For future work some other points can be considered in order to improve both the RIG final results and the main purpose as an educational game:

1. Consider other scenarios of the activities relationships and the planned schedule type.
2. Allow the user to prepare the actual Vs planned schedule to feel the impact of the risks on duration and he/she may claim for extra time for reasonable reasons and the instructor may or may not approve.
3. Apply penalty per day for delay while allowing engineers to manage schedule.
4. Expand the risk factors, prevention actions and mitigating actions from other projects' databases.
5. Adding different construction methodologies and how to choose between them can be another useful option to be added to the model.
6. Use the triangle impact curve and the two different impacts for the same probability percentage in order to maintain the results' diversification and non-repetition.
7. Allowing "Ask Instructor" button during the game may contribute to the self-learning process, but will need with that expanded risk/mitigating measures and the Risk management procedure explanation menus to be effective.

8. Use “audio” for both the narrative and the process explanation texts instead of reading, which could be more attractive and easier.

REFERENCES

Al-Jibouri, H. Saad and Micheal J.Maudesley (2001), Design and experience with a computer game for teaching construction project planning and control,*Engineeringconstruction and architectural management*: 8 5/6, pp. 418-427.

Allery, Lynne A. (2004), Educational games and structured experience, *Medical teacher journal*, Vol. 26, No. 6, pp. 504-505.

Au, T., Bostleman, R.L. and Parti E. (1969), Construction Management Game – Deterministic Model, *ASCE Journal of Construction Division*, Vol.95, pp. 25-38.

Aven, Terje, Zio, Enrico (2011), Some considerations on the treatment of uncertainties in risk assessment for practical decision making, *Reliability Engineering and system safety Journal*, Vol. 96, pp. 64-74, 2011.

Baldwin, James S., et al. (2006), Management Decision-Making Risk Reduction Through Simulation, Risk management, Vol.8, pp. 310-328. www.palgrave-journals.com/rm.

Bilsen, Arthur van, Bekebrede, Geertje, Mayer, Igor (2010), Understanding Complex Adaptive Systems by Playing Games, Informatics in Education, Vol.9, No. 1, pp.1–18, http://www.mii.lt/informatics_in_education/pdf/INFE160.pdf

Chan, Albert P. C., Chan, Ada P.L. (2004), Key performance indicators for measuring construction success, *Benchmarking: An International Journal*, Vol. 11 No. 2, pp.203 - 221.

Chan, Swee Lean and Park, Moonseo (2005), Project cost estimation using principal component regression, *Construction Management and Economics*, Vol. 23, No. 3, pp.295 - 304.

Davidovitch, L, Parush, A., Shtub, A. (2008), Simulation-based Learning in Engineering Education: Performance and Transfer in Learning Project Management, *Journal of Computers & Education*, Vol. 50, No. 3, pp. 866–880, April 2008.

Digital library of Mathematical Functions (2012), National Institute of Standards and Technology from http://dlmf.nist.gov/, last checked at 16/8/2012.

Doloi, Hemanta (2008), A self-learning educational framework for online delivery, *http://www.ics.heacademy.ac.uk/italics/vol6iss1/doloi.pdf*.

Han, Sangwon (2011), Interactive PARADE game: IMPACT OF MANAGERIAL REACTIONS TO WORKFLOW VARIABILITY, *Journal of Information Technology in Construction* (ITcon), Vol. 16, pp. 105-118,

Hegazy, Tarek (2006), Simplified Project Management for Construction Practitioners, *Cost engineering Journal,* Vol. 48, No. 11, pp. 20-28, November 2006.

Henesey, Lawrence, Davidsson, Paul, and Persson, Jan A. (2008), Agent based simulation architecture for evaluating operational policies in transshipping containers, *Springer Scince+Business Media, LLC,* No. 18, pp. 220-238, 2008.

Juul, Jesper (2005), Half-Real, Video Games between Real Rules and Fictional Worlds, Cambridge, MA: MIT Press, 2005.

Klassen, Kenneth J. and Willoughby, Keith A. (2003), In-Class Simulation Games: Assessing Student Learning, *Journal of Information Technology Education,* Vol. 2, 2003.

Mekkawi, Hosnachah A. R. (2006), A computer-Aided-Learning Tool for Teaching Construction Decision Making: An Excavation Stage Educational Game, Thesis, The American University in Cairo AUC.

Mbachu, J.I.C. and Vinasi thamby, K. (2005), Sources of risks in construction project development: An exploratory study, *Queensland University of Technology Research Week International Conference, Compendex Database*, July4-8, 2005.

Nassar, Khaled (2001), Managing Construction Equipment Buy and Sell Decisions Replacement: A Simulation Game, *ASC Proceedings of the 37th Annual Conference*, pp 187-198, April4-7, 2001.

Nassar, Khaled (2002), Pricing Construction Contracts in a Competitive Market: A Simulation Game, *ASC Proceedings of the 38th Annual Conference*, pp47-54, April 11-13, 2002.

Nassar, Khaled and Al-Khatib, Anas (2002), An Interactive Multimedia Case Study for Teaching Legal Concepts in Construction, *ASC Proceedings of the 38th Annual Conference*, pp 41-46, April 11-13, 2002.

Nassar, Khaled (2001), Developing an Interactive Lecture-On-Demand Tutorial for Teaching Construction Scheduling Basics, *ASC Proceedings of the 37th Annual Conference*, pp 13-20, April 4-7, 2001.

Okmen, Onder, and Oztas, Ahmet (2008), Construction Project Network Evaluation with Correlated Schedule Risk Analysis Model, *Journal Of Construction Engineering and management*, Vol. 134, No. 1, January 1, 2008.

Project Management Institute Standards Committee, (2009).A guide to the Project Management Body of Knowledge 4th edition (PMBOK). Upper Darby, PA: Project Management Institute.

Sacks, R., Esquenazi, A. and Goldin, M. (2007), LEAPCON: Simulation of Lean Construction of High-Rise Apartment Building, *Journal of Construction Engineering and management*, Vol. 133, No. 7, pp. 529-539, Jul 2007.

Sawhney, Anil, Mund, Andre, Koczenasz, Jeremy (2001), Internet-Based Interactive Construction Management Learning System, *Journal of Construction Education*, Vol. 6, No. 3, pp. 124-138, Fall 2001.

Tserng, H.P., and Chang, C.H. (2008), Developing a project knowledge management framework for tunnel construction: lessons learned in Taiwan, *Canadian Journal of Civil Engineering*, 35: 333-348, April 2008,

Vinnem, Jan Erik (2007), Offshore Risk Assessment: Principles, Modeling and Applications of QRA Studies, by Vinnem, Jan Erik, 2nd Edition, Springer Series in Reliability Engineering, 2007

Weaver, Patrick (2010), The effective management of Time on Mega projects (Why are there so many problems and how to solve them?), ICC2010 Conference "Challenges of global mega projects innovations & creativities for project excellence", October 12-13, 2010, http://www.scribd.com/doc/60429763/Management-of-Time-1.

Wideman, R.Max (2001), Project Management Appraisal: Testing the Effectiveness of Your Project's Management, *A paper presented to the International Seminar on Project Management for Developing Countries, September 4 to 6, 1991, in New Delhi, India.*pp. 1-17, AEW Services, Vancouver, BC ©2001

Yaoyuenyong, Charnkurt, and Hadikusumo (2005), B.H.W., et al., Virtual Construction Negotiation Game – An Interactive Learning Tool for Project Management Negotiation Skill Training, *International Journal of Business & Management Education*, Volume 13(2), ISSN 1832-0236, pp. 21-36, 2005.

APPENDIX A: DESIGN OUTCOMES

Item	Value
Sealine length (Km)	30
Sealine diameter (Inch)	16
Structure weight (Ton)	2,500
Survey vessel daily rate (US$ K)	80
Laying barge daily rate (US$K)	250
Laying barge capability (Km/)day)	1.4
Installation barge daily rate (US$K)	195
Steel pipes price $/Km	313
Platform material $/Kg	1,750
Coating factory price $/Km of PL	265

Table (1) Sample design outcomes

Activity	Duration	Start	Finish	Float
Project approval	0	24/Mar/2010	24/Mar/2010	0
Sealine survey	25	24/Mar/2010	17/Apr/2010	0
Sealine survey report	0	17/Apr/2010	17/Apr/2010	0
Platform survey	5	24/Mar/2010	28/Mar/2010	20
Platform survey report	0	28/Mar/2010	28/Mar/2010	20
Engineering	0	18/Apr/2010	14/Oct/2010	0
Purchasing sealine pipes (LLI)	210	15/Oct/2010	12/May/2011	116
Purchasing platform structural material (LLI)	270	15/Oct/2010	11/Jul/2011	0
Purchasing sealine accessories	90	15/Oct/2010	12/Jan/2011	296
Purchasing platform production facilities	240	15/Oct/2010	11/Jun/2011	150
Sealine coating	60	13/May/2011	11/Jul/2011	116
Platform fabrication	120	12/Jul/2011	08/Nov/2011	0
Sealine laying	21	12/Jul/2011	01/Aug/2011	116
Platform installation	120	09/Nov/2011	13/Nov/2011	0
Sealine tests	3	02/Aug/2011	04/Aug/2011	116
Platform commissioning	15	14/Nov/2011	28/Nov/2011	0
Project completion	0	28/Nov/2011	28/Nov/2011	0
Σ	1179	24/Mar/2010	28/Nov/2011	

Table (2) Sample planned schedule

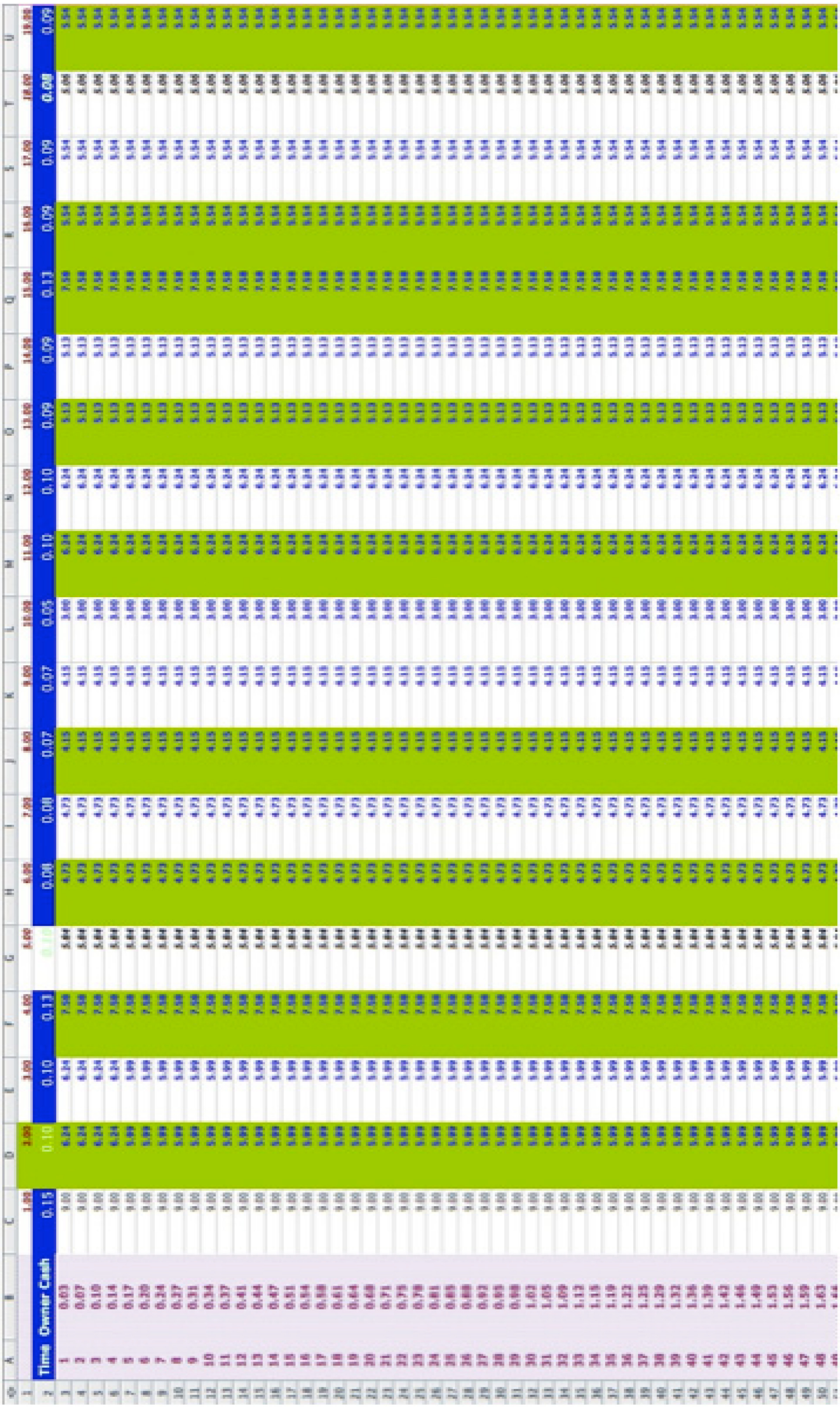
Project Activities				
Activiy ID	**Activity Name**	**Normal Dur**	**Normal Cost (US$ K)**	
S001	Project approval	-	$ -	
P001	Sealine survey	25	$ 2,000.00	
S002	Sealine survey report	-	$ -	
P002	Platform survey	5	$ 400.00	
S003	Platform survey report	-	$ -	
P003	Engineering	115	$ 4,000.00	$ 6,400.00
M001	Purchasing sealine pipes (LLI)	210	$ 9,390.00	
M002	Purchasing platform structural material (LLI)	270	$ 4,375.00	
M003	Purchasing sealine accessories	90	$ 6,200.00	
M004	Purchasing platform production facilities	240	$ 7,500.00	$ 27,465.00
C001	Sealine coating	60	$ 7,950.00	
C002	Platform fabrication	120	$ 9,953.00	$ 17,903.00
C003	Sealine laying	21	$ 5,250.00	
C004	Platform installation	5	$ 975.00	$ 6,225.00
C005	Sealine tests	3	$ 507.00	
C006	Platform commissioning	15	$ 1,500.00	$ 2,007.00
S004	Project completion	-	$ -	
Total Budget without contingency		**1,179**	**$ 60,000.00**	**$ 60,000.00**

Table (3) Sample project activities

APPENDIX B: LIST OF MITIGATING ACTIONS AND THEIR IMPACT

Associated Risks	Code	number	Mitigating/preventive actions	Impact on risk Cost	impact on risk Schedule
Delay due to custom clearance	B	1	preventive: special permits as early as possible (right after purchase orders issuance)	100.00%	100%
	B	2	Preventive: a team work who is dedicated to follow up getting all permits in time	99.80%	100%
	A	3	Mitigating: Recruit a clearance Agency	99.50%	50%
Market conditions that affects steel prices	B	1	preventive: the contract should be fixed price (lumpsum)+currency should be fixed to the sign of contract date	100%	100%
	B	2	Preventive: condition in the contract that incase of market / currency prices increased, the contract price will be +X%	99%	99%
			Noticing that the impact could be either -ve or +ve		
lack of material in local market	B	1	preventive: investigate material availability in locat market during the engineering phase & assign a special crew for following up material delivery	90%	80%
	B	2	preventive: order +20% of the required material as contingency	100%	99.80%
	A	3	mitigating: Transfere risk to third party (insurance company)	90%	100%
	A	4	mitigating: change order so the contractor scope includes material delivery	75%	75%
Coating factory occupancy	B	1	preventive: reserve your coating window right after issueing purchase orders, through asking the coating factory to provide their annual plan	99.8%	100%
	A	1	mitigating: negotiate with another factory	50%	50%
	A	2	mitigating: negotiate with factory to start partially untill coating line is available	90%	10%
Intervention works preventing surveying equipment from approaching	B	1	Preventive: SIMOP, to define operations with other companies in this area and make an agreement including activities, durations…etc.	100%	100%
	A	1	Mitigating: choose another rout if available, incase of installations activities	0.5%	50.00%
	A	2	Mitigating: joint arrangement with other companies operating in the area	0.5%	2%
Mechanical problems for surveying equipment	B	1	Preventive: inspection & validity certificates for critical equipment before start working	80%	80%
	B	2	Preventive: ask the contractor to prepare additional spare parts for the critical equipment (i.e. ROV, etc.) resulting very low impact on time but moderate impact on cost. "mainly contractor responsibility"	5%	90%
	A	1	Mitigating: engage contractor in resolving the surveying equipment problem	0%	80%
Mechanical down time during pipe laying	B	1	Preventive: proper contracting for transportation company - including insurance	100%	95.00%
	A	1	Mitigating: engage platform fabrication contractor on site in order to manage damage	90%	70%
	B	2	preventive: transfere the risk to third party "insurance company" incase of damage in the PL	90%	0%
	A	2	mitigating: abandon the PL and fix the barge. Full responsibility of the contractor	100%	0.00%
	B	3	Preventive: order standby equipment	1%	100.00%
	A	3	Mitigation: involve international expertise to manage new technology	0%	90%
Incomplete Material List affecting the fabrication yard schedule	B	1	Preventive: hire a highly qualified engineering company. Hire a third party for engineering revision	50%	99.5%
	B	2	preventive: order +20% of the required material as contingency	80%	100%
	A	1	Mitigating: order missing materials through contractor	0%	0%
Weather down time during platform installation	B	1	Preventive: avoid bad weather time in scheduling	50%	50%
	A	1	mitigating: work any way and take all the risk	1%	80.00%
	B	2	preventive: transfere the risk to third party "insurance company" incase of damage in the PL	90%	0%
	A	2	Abandon the PL and stand by during bad weather period	0%	0%
Change in design leads to change order	B	1	preventive: scope of work should be defined clearly with the contractor	50%	50%
	B	2	preventive: avoid change in design through revised FEED and hire third party to revise engineering	50%	90.00%
Change rout due to environmental permits	B	1	Preventive: follow up team to ensure permits issued prior to start installations	99.8%	100%
	B	2	Preventitve: engage authorities in environment survey - to get approved license to operate during engineering phase	100%	100%
	A	1	Mitigating: try first to negotiate incase of neighboring equipment exists, then you may have to change rout any way but if you have ordered +20% of pipeline material this action may have low impact on time.	1%	0%
Personnal permits for the offshore work	B	1	Preventive: a team work who is dedicated to follow up getting all permits in time	99.8%	100%
Pipeline Leak	B	1	Preventive: stock chemical dispercents and standby marine vessel, ROV	5.0%	90%
	B	2	Preventive: involve insurance companies in carrying cleaning cost	90%	0%
	A	1	Mitigating: Engage regional companies' marine resources	0%	80%

APPENDIX C: SNAP SHOT OF THE 500 TRIALS FULL RESULTS TABLE



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
		1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00
Time	Owner Cash	0.15	0.10	0.10	0.13	0.10	0.08	0.08	0.07	0.07	0.05	0.10	0.10	0.09	0.09	0.13	0.09	0.09	0.08	0.09
1	0.03	9.00	6.24	6.24	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
2	0.07	9.00	6.24	6.24	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
3	0.10	9.00	6.24	6.24	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
4	0.14	9.00	6.24	6.24	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
5	0.17	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
6	0.20	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
7	0.24	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
8	0.27	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
9	0.31	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
10	0.34	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
11	0.37	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
12	0.41	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
13	0.44	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
14	0.47	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
15	0.51	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
16	0.54	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
17	0.58	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
18	0.61	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
19	0.64	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
20	0.68	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
21	0.71	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
22	0.75	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
23	0.78	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
24	0.81	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
25	0.85	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
26	0.88	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
27	0.92	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
28	0.95	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
29	0.98	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
30	1.02	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
31	1.05	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
32	1.09	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
33	1.12	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
34	1.15	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
35	1.19	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
36	1.22	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
37	1.25	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
38	1.29	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
39	1.32	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
40	1.36	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
41	1.39	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
42	1.42	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
43	1.46	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
44	1.49	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
45	1.53	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
46	1.56	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
47	1.59	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
48	1.63	9.00	5.99	5.99	7.58	5.84	4.73	4.73	4.15	4.15	3.00	6.24	6.24	5.13	5.13	7.58	5.54	5.54	5.06	5.54
49	1.66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX D: ENGINEERS EVALUATION RESULTS

M1	
the full resultnumber of prevention	4
Numper of passes	0
Numper of Actions	0
times of intersets	
861.6767996	
891.7330848	
921.7893699	
951.8456551	
981.9019403	
1011.958225	
1041.968053	
1072.002067	
1102.03608	
1132.070094	

M2	
the full resultnumber of prevention	3
Numper of passes	0
Numper of Actions	1
times of intersets	
856.8855535	
886.934334	
916.9831144	
947.0318949	
1003.373358	
1033.382678	
1063.413857	
1093.445036	
1123.476215	

M3	
the full resultnumber of prevention	3
Numper of passes	0
Numper of Actions	2
times of intersets	
858.1721092	
888.2058803	
918.2396514	
948.2734225	
978.3071936	
1008.340965	
1038.356966	
1068.388146	
1098.419325	
1128.450504	

M4	
the full resultnumber of prevention	4
Numper of passes	0
Numper of Actions	1
times of intersets	
862.3822405	
892.605505	
922.8287696	
953.0520341	
983.2752986	
1013.498563	
1043.515968	
1073.566421	
1103.582294	
1133.598167	

M5	
the full resultnumber of prevention	5
Numper of passes	0
Numper of Actions	1
times of intersets	
858.975111	
889.0313962	
919.0876814	
949.1439666	
994.0595388	
1024.076897	
1054.11091	
1084.144924	
1114.178937	

M6	
the full resultnumber of prevention	4
Numper of passes	0
Numper of Actions	1
times of intersets	
860.2626642	
890.3189493	
920.3752345	
950.4315197	
998.7242026	
1028.741497	
1058.77551	
1088.809524	
1118.843537	

APPENDIX E: THE RIG EVALUATION QUESTIONNAIRE FORMS

RIG evaluation Questionnaire form

	Strongly agree "4"	Agree "3"	Uncertain "2"	Disagree "1"	Strongle disagree "0"
1- The game reflects real risk problems		✓			
2- The game provides enjoyment		✓			
3- The game is assisting in risk management learning			✓		
4- The game time was enough		✓			
5- The game produces fare results reflecting the decisions you made			✓		
6- The game interface is clear and simple		✓			
7- The game promotes self learning		✓			
8- The game is easy to use		✓			

Questionnaire form Q1

RIG evaluation Questionnaire form

	Strongly agree "4"	Agree "3"	Uncertain "2"	Disagree "1"	Strongle disagree "0"
1- The game reflects real risk problems	✓				
2- The game provides enjoyment		✓			
3- The game is assisting in risk management learning	✓				
4- The game time was enough	✓				
5- The game produces fare results reflecting the decisions you made	✓				
6- The game interface is clear and simple	✓				
7- The game promotes self learning	✓				
8- The game is easy to use	✓				

Questionnaire form Q3