

The Establishment of Safety Risks Management and the Simulation of Construction Projects Based on the PMBOK Standard and the Monte Carlo Method (Case Study: Atlas Plaza Project)

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ABSTRACT

Due to its particular nature, the construction industry is one of the most perilous industries and, on average, takes more occupational damages compared to other industries. Many researches have been conducted that show how construction risks are controlled and how construction safety programs prevent damage. In order to reduce the damage rate and thus the final cost of projects, developed and developing countries need to implement full-scale safety programs, such as a comprehensive management.

One of such programs is the risk management program in compliance with the PMBOK standard. Due to the holistic approach of the standard, however, we will provide a detailed model in this research, so that the safety risks will be managed, identified, qualitatively prioritized and quantitatively analyzed (employing a simulation of Monte Carlo to calculate the final cost and time), and then we will respond to questions and monitor it.

It should be noted that the provided model was implemented in the Atlas Plaza project in Tehran in order for its efficiency to be studied.

KEYWORDS: Risk Management, the Construction Industry, the Monte Carlo Approach, PMBOK

1- INTRODUCTION

Due to its particular nature, the construction industry is one of the most perilous ones and is averagely receiving more occupational damages compared to other industries [1]. Many researches showing the method of controlling the risks of construction and preventing damages through safety construction programs have been conducted. In developed and developing countries, in order to reduce the damage rate and therefore reducing the final cost of projects, full scale safety programs such as comprehensive management need to be implemented[2].

The ultimate goal of project management is the successful completion of construction and industrial projects within the intended budget, time and quality and satisfying the project beneficiaries. The knowledge of project management has been seeking to reach this goal by introducing instruments for a better management of the nine dimensions of project management (time management, cost management, risk management, scope management, etc.). Project management is also defined as a formal, structured, precise method of change management [3]. Techniques such as the critical path method, earned value management and risk management have long been introduced to successfully carry out projects and the implementation of such techniques now prevails in the country's projects to some extent. Our country, too, is setting out to implement modern techniques of project management to enhance its level of safety, and this has led to dramatic changes in some companies. Only those companies will perform well at the administrative affairs of project management that are able to foresee upcoming changes and react quickly to them. Therefore, devising and deploying project management system is necessary for project-based organizations. Thus, construction teams must set safety as their top priority[4]. A construction team consists of an employer, an

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engineer/architect, a general contractor, a construction manager, specialized contractors and equipment suppliers. It is the responsibility of the construction team to ensure that the completion of the project will not be jeopardized and that it will economically meet an acceptable level of quality [5].

A realistic assessment of the conditions of construction projects in the country will make it clear that, in terms of quality and potential risks, the construction industry must be given serious consideration. Therefore, an analytical investigation of the two aforementioned factors will be useful only if proper approaches towards the path of construction are adopted [6]. Although providing project risk management in the process of construction faces numerous obstacles, establishing it can bring benefits such as high incomes and interest rates [7, 8]. The design of the system and its applicability need to be understandable as well as variable so that there will be no need for a redesign in future construction projects, and that, in different circumstances, the system can be reapplied with slight changes in the framework. Therefore, the design of a system being based on an internationally accepted standard will increase the confidence level and the reliability of the system. According to the years-long record of applying systems, different models and methodologies have been introduced by various intellectuals. One of the methodologies in project management is the Project Management Body of Knowledge guide which has been developed by the Project Management Institute. This guide aims to introduce the different domains of Project Management Body of Knowledge through a systematic approach.[9]

The analytical project approach of the PMBOK standard is what distinguishes this standard and how it views risk management from other available sources. This standard, aside from considering all aspects of a project, generally tries to present computational solutions to conduct a quantitative and qualitative analysis of the goals of the project. Since a proper risk management in a safety project leads to the identification of all of its potential risks and, eventually, with proper evaluation and control and selecting the best possible way of facing the risks, brings about a decrease in the perilous factors and an increase in the level of safety, it is recommended that, following an enhancement of the level of safety of the construction industry in safety projects and development projects through project risk management with the cautions advised in the PMBOK standard in mind, this research be applied onto the Atlas Plaza project in Tehran so that the knowledge of project management is practiced in a compiled, repeatable, and systematic way and becomes applicable in all construction projects.

2. Research Background

Using a systematic model to manage and mitigate risks in the context of the implementation of development projects will bring beneficial results for the satisfaction of stakeholders. Discussion of project risk management in recent years, especially in the late nineteenth century was proposed more seriously. Risk management techniques have tried for many years, but it is a short time since these techniques have entered the field of project management [10]. However, looking at the research done, we get familiar with ideas presented in the following.

In a study carried out by Kisar and his colleagues on risks in construction projects, according to the standard of Project Management Body of Knowledge (PMBOK), evaluation of risk in construction projects, and estimating the risk events to assess the level of safety of the project are developed in which the risk level is calculated by a project team, and relevant preventive and corrective measures are taken [11].

In another study, Antonio, and colleagues examined the application of project management standards and develop a tool to assess success factors for project management, focusing on evaluation of project management practices for specific construction projects. They have tried to identify the success factors and risks discussed the possible construction projects according to PMBOK standard, and to explain how this standard can be used as an integrated tool to evaluate project management [12].

Xiav and colleagues, in a study on the risk management of construction projects in Singapore, done to determine the allocation of resources, effectiveness, impact, and understanding of risk management in the construction project, they used questionnaire to achieve the targets and it was found that the larger part of the costs are invested on time and labor. It was also concluded that there is low level of understanding and awareness of project risk management in organizations [13]. In internal studies done, Islami Baldeh and colleagues in a study of optimal choice of safety in the management risk control measures, according to the stages related to evaluation of risk management in PMBOK standard offered a new method to optimize risk control measures in which investigating the objectives and constraints in the optimization problem with respect to the control measures, and the effectiveness of control measures are discussed. In this study, as the data obtained from risks and the control measures obtained have uncertainty according to the experts, for optimization, fuzzy variables, followed by zero-a fuzzy linear programming are used [14]. In domestic and international levels, research related to promotion of safety has a history over several decades. Although these studies seem to be much more significant and more comprehensive in the oil and petrochemical industries, in the manufacturing industry in recent decades, extensive research and studies have been done. About issues related to management in order to achieve greater safety, maybe the emergence of the evaluation models is nearly several

decades. However, although research about the costs and factors involved in research projects in nearly half a century old, safety-related research in our country does not have a long history. Therefore, during the investigations, those listed, were only the cases of several studies that are subject to advance this study.

3. MATERIALS AND METHODS

The population in this study is Atlas Plaza project located in Abbas Abad near the Museum of Sacred Defense. Due to poor documentation and lack of access to recorded information projects, one of the richest and most reliable sources of information is the experience of the experts. In order to collect and evaluate stakeholders and executives ideas, in the project, questionnaire technique was used due to the scattering of construction and the problems associated with face-to-face interviews with more people. The practical use of the questionnaire is to collect the opinions of people and quantitative analysis and prioritization of risk causing factors.

The methodology of the project includes several phases, which are as follows:

3.1. Plan for Safety Risk Management of Project:

Initially, after recognizing the necessity of implementing risk management, participants of the planning meeting were selected from among experienced, skilled and knowledgeable of the responsibility of the project studied. The project manager, director of project services and project experts and generally risk management team attended the planning meeting and issues of mission and purpose of this research, risk management position in the organization chart, projects risk classification, budgeting and the required timeframe, the possible definitions and risk effect were prepared with the consent of those present. The classification of risk (providing the desired Risk Breakdown Structure RBS) was on the agenda. RBS can help the project team identify project risks. Therefore, in project-risk management regulations, all possible scenarios for RBS should be examined and used in different conditions. RBSs of the projects include the following. This classification is based on OSHA

Figure 1. Classification of risks according to OSHA



3.2. Identifying safety risks of the project:

Then safety risks that could affect project objectives (time, cost, quality) were identified. The approach used in this stage was brainstorming sessions and documentation included in the project (FMEA approach). These risks are shown with quantitative results.

3.3. Qualitative analysis of the identified risks:

At this point, using a questionnaire, we determined the probability of risks occurring and determining the effect of each risk on the project objectives.

The questionnaires were distributed among fifteen experts and project managers, and the basis for the preparation of the questionnaire was the major risk factors identified in the previous step and comments of advisors, experts in the field and the various articles were used to prepare the questionnaire.

Before the analysis, it is needed to standardize the questionnaire.

To standardize a questionnaire, It is necessary to evaluate its validity and reliability, so we describe it.

Validity:

The validity is derived from the term "valid" meaning permissible and correct and validity means being true and correct. In fact, the concept of validity answers the question that how much the assessment tool measures the intended character. Without knowledge of the validity of the instrument, one cannot be sure of the accuracy of the data.

Measuring instrument may be valid to measure one feature, but to measure the same attribute on another community it may not have any credit.

Face validity:

Face validity based on a questionnaire that was developed and released among 12 of experts was very good.

Content validity:

A test has good content validity, when it measures all axes that those tools are expected to measure. Content analysis of a test is somewhat subjective, and if some experts confirm a subject after content analysis, it can be cited.

Lavsheh method is of quantitative methods to determine the content validity that is widely accepted. In this method, a group of experts is asked to discuss the importance and necessity of each question of the questionnaire. To assess content validity using this method, the following should be taken into consideration. Experts should be appointed in such a way that they have knowledge and skills needed in the context of the study.

The method of using the research tool, goals, and the field studied should be described to them.

In this method, the experts will be asked to assess questions of the questionnaire based on the following classification Important and relevant

Relatively important and relevant

Unimportant and irrelevant

Content validity ratio (CVR): This index was designed by Lavsheh. In order to calculate this indicator, the opinions of experts in the field can be used to test content. And by explaining the exam objectives to them and providing operational definitions related to the content of the questions, they are asked to classify each of the questions on the basis of the whole three-part Likert "essential items", "items is useful but not essential "and "unnecessary items." Then, based on the following formula, the content validity ratio is calculated:

$$CVR = \frac{n_E - \frac{N}{3}}{\frac{N}{3}}$$

Where nE is the number of professionals who selected essential options, and N is the total number of professionals Base table is as follows

Table 1: Lavsheh Table

Minimum validity value	The number of people on experts panel
0.99	5
0.99	6
0.99	7
0.85	8
0.78	9
0.69	10
0.49	15
0.42	20
0.37	25
0.33	30
0.29	35

That only one case of identified risks had CVI as 0.4 that was removed.

CVI scale calculation of the questionnaire:

In Lavsheh method, for quantitative determining of the content validity of the questionnaire, content validity index is calculated. To calculate it, first all the questions whose CVR is less than the minimum acceptable CVR are eliminated. Then the mean scores of the remaining questions are calculated as the final content validity index of questionnaire.

CVI formula is as follows:

$$CVI = (38 \times 1) + (16 \times 0.8) / 54 = 0.94$$

$$CVI = \frac{\sum_n^1 CVR}{\text{Retained numbers}}$$

According to the above figures, it is identified that the questionnaire has good content validity.

The reliability of the questionnaire:

Trustworthiness that words like stability and credit are used for and its English equivalent is reliability is one of the characteristics of the measurement tool (questionnaire). The concept mentioned deals with to what extent the measuring tool provides the same results in the same conditions.

Of the definitions given to the reliability, the definition by Abel and Ferysiy can be noted, "The correlation between a set of scores, and another set of scores on a test that are obtained independently on a group of subjects."

Given that our target population has been only professionals, we did not have so many people, so because of non-normal population, we cannot use Cronbach's alpha. Thus, we used Internal correlate coefficient ICC method. We distribute the questionnaires among ten people in two steps, then we entered the data into SPSS 22 software, then put the mean of all the columns in one column, MEAN1 in the first time, and MEAN 2 were obtained in the second time, then the correlation between the two columns was acquired with software as follows:

Table 2: Intraclass Correlation Coefficient

	Intraclass Correlation ^b	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound			Lower Bound	Upper Bound
Single Measures	.840 ^a	.794	.876	Single Measures	.840 ^a	.794	.876
Average Measures	.913 ^c	.885	.934	Average Measures	.913 ^c	.885	.934

Given the high correlation coefficient, it is indicated that the questionnaire has high reliability and is reliable.

Given that the questionnaire is standardized, we went on. In the continuation of this stage, to determine the extent of occurrence of risks and to determine their effects on the project goals, the mentioned questionnaire is used. Thus, the questionnaire was distributed between the 15 members of the Risk Management team in Atlas Plaza.

This questionnaire is solely prepared for gathering comments of stakeholders on the impact on project outcomes and the likelihood of its occurrence in the project and it is not used to test fitting and testing hypotheses. In other words, this questionnaire does not look for measuring the compatibility of the measure and there is no need to normalize the population.

The process of analyzing the questionnaires was as follows:

1. Calculating the frequency of each of the options for each question for probability and on time, cost and quality
 2. Calculating the percentage of each item by dividing the frequency of each option on the total responses for that option
 3. Determining the average results of each risk factor, the product of the frequency of each option in the options rating
- For scoring, in order to determine the probability of occurrence, numbers 0.9, 0.7, 0.5, 0.3, 0.1 and for the effects of risk on the time, cost, and quality, numbers 0.8, 0.5, 0.4, 0.2, 0.1 are used based on the PMBOK standard. The above steps were done on all the questionnaires and finally the average results for the probability of the project are done on time, cost, and quality. The numbers and analyses are considered as input stage in quantitative risk assessment.

Risk analysis is a process that assesses the impact and likelihood of occurrence of identified risks. This process prioritizes risks based on their impact to the project objectives. In this study, according to the average probability and risk impact, the probability and impact matrix method are selected for qualitative analysis of selected risk to do the analysis. Three stages are intended for the qualitative analysis of risk in the system including:

1. From the mean results of time, cost, and quality factors, we choose the one that has the greatest impact on the projects
2. Calculating the amount of risk for the maximum effect of the probability of occurrence of each risk
3. Prioritizing risk factors based on the amount of risk in a descending order

It should be noted that the above steps were done in EXCEL 2010 software and according to the formula.

Three steps listed were done on identified risks of Atlas Plaza project; the following table summarizes the results.

Table 3: The results of the risk assessment

Row	Risks studied	Possibility	Effect			Risk
			Time	Cost	Quality	
HSE management risk						
1	Lack of planning of HSE management system of contractor before contract	0.73	0.47	0.48	0.39	0.35
2	Writing contracts, regardless of the level of project risk	0.62	0.53	0.71	0.34	0.44
3	Lack of preliminary identification of risks	0.62	0.39	0.46	0.43	0.29
4	The lack of clarifying safe gathering place	0.54	0.60	0.34	0.28	0.32
5	Lack of development of documentation and records of contractor HSE management	0.54	0.39	0.34	0.28	0.21
6	Lack of development of HSE Employer Plan (HSE PLAN)	0.66	0.34	0.50	0.29	0.33
7	Lack of evaluation of contractors HSE plan	0.66	0.45	0.47	0.31	0.31
8	Lack of establishing HSE management system requirements	0.86	0.37	0.71	0.28	0.61
9	Failure to implement document control system	0.61	0.41	0.40	0.35	0.25
10	Failure to define minimum requirements for HSE management of contractors in general terms and specific Treaty	0.67	0.49	0.53	0.44	0.36
11	Lack of appropriate financing of HSE unit	0.84	0.83	0.43	0.35	0.70
12	Unimportance of HSE in terms of management and lack of support	0.63	0.50	0.49	0.38	0.32
13	Lack of the deployment of personnel training in HSE unit	0.61	0.41	0.45	0.33	0.27
14	Not caring about technical committee meetings in workshop	0.54	0.55	0.55	0.39	0.30
15	Lack of safety culture in the workplace	0.87	0.78	0.55	0.39	0.68
16	Out of organization problems to increase safety	0.62	0.35	0.30	0.28	0.22
17	Failure to use proper safety officer	0.63	0.47	0.49	0.35	0.31
18	Lack of adequate training for staff and workers by the HSE Unit	0.60	0.50	0.48	0.39	0.30

Continuation of Table 3

Row	Risks studied	Possibility	Effect			Risk
			Time	Cost	Quality	
Risks of cranes and machinery						
19	Lack of inspection and checking construction machines	0.55	0.51	0.55	0.43	0.30
20	Lack of maintenance and inspection of tower crane and lift	0.63	0.53	0.55	0.41	0.35
21	Non-compliance with vehicle traffic regulations	0.57	0.44	0.45	0.35	0.26
22	The lack of inspections of active operators and driver's license in the workshop	0.58	0.51	0.51	0.52	0.30
23	Unauthorized people's ride on loaders, graders, bulldozers and ...	0.63	0.48	0.47	0.47	0.30
24	Non-observance of safety repairs when repairing equipment and machinery	0.70	0.47	0.48	0.42	0.34
25	Non-compliance with safety in manual tools	0.66	0.39	0.35	0.37	0.26
Risks of scaffolding and ladders						
26	Defects in coupler	0.30	0.50	0.59	0.40	0.18
27	Broken Ladders board	0.30	0.60	0.70	0.40	0.21
28	Failure to establish proper scaffolding	0.30	0.30	0.30	0.40	0.12
29	Non-use of net when working with scaffolding	0.30	0.20	0.59	0.40	0.18
Risks of excavation and demolition						
30	Lack of safety in the degradation of (excavation)	0.75	0.60	0.59	0.47	0.45
31	Lack of safety in excavation	0.70	0.59	0.58	0.54	0.41
32	Lack of safety in wells and drilling and pile	0.66	0.51	0.53	0.41	0.35
33	Lack of proper nailing	0.55	0.61	0.58	0.43	0.34
34	The lack of use of detailed mapping calculations of excavation and drilling	0.70	0.70	0.60	0.50	0.49

Continuation of Table 3

Row	Risks studied	Possibility	Effect			Risk
			Time	Cost	Quality	
	Risks of working in concrete and metal structures					
35	Lack of proper placement of facilities	0.63	0.55	0.55	0.39	0.35
36	Non-compliance with ergonomics or human factors engineering in heavy work such as concrete	0.65	0.37	0.40	0.44	0.28
37	Non-compliance with safety in pressure cylinders	0.65	0.53	0.51	0.41	0.34
38	Lack of safety in batching	0.62	0.42	0.49	0.36	0.30
39	Lack of safety in welding and cutting	0.67	0.40	0.44	0.39	0.30
	General risks					
40	Non-compliance with personal protective equipment by staff and workers Non-compliance with personal protective equipment by staff and workers	0.62	0.43	0.55	0.34	0.34
41	Critical cases such as earthquakes and floods	0.46	0.66	0.66	0.57	0.30
42	Lack of proper lighting in the workplace in the night	0.63	0.49	0.51	0.52	0.33
43	Safety in the transport and storage of materials	0.65	0.46	0.50	0.28	0.32
44	Failure to use the proper tools in working with noise things like the use of chipping and ...	0.63	0.27	0.33	0.39	0.24
45	Failure to install appropriate warning signs in workshops	0.63	0.39	0.41	0.33	0.26
46	Lack of safety in the workplace setting	0.30	0.44	0.52	0.29	0.39
47	Lack of cleaning the workshop	0.63	0.44	0.35	0.34	0.28
48	Failure to comply with public health issues such as drinking water workshop	0.62	0.36	0.40	0.31	0.25
49	Recording and appropriate workplace relevance	0.67	0.51	0.51	0.42	0.35
50	Failure to observe basic safety principles and the absence of proper electricity ear thing system	0.65	0.49	0.58	0.41	0.38
51	The lack of fire extinguishers installed in the workshop	0.62	0.40	0.52	0.45	0.32
52	Lack of availability of suitable capsules for each type of fire	0.61	0.39	0.41	0.38	0.25
53	Lack of appropriate equipping of the equipment workshop during the early equipping (like roads and building administrative and engineering)	0.30	0.49	0.53	0.44	0.16
54	Lack of privacy enclosing of workshop (install shield, revolving lights and reflective, etc.)	0.59	0.45	0.49	0.37	0.29
55	The lack of clear entry and emergency exit routes	0.54	0.38	0.43	0.30	0.23

After identifying risks and prioritizing them and knowing what risks need to be further investigated, to identify their effects on Atlas Plaza project performance, in this section, by using expert opinions of the risk management team, the numerical value of risks and their impact on project are analyzed. In this regard, Pert Master software was used.

3.4. Quantitative Risk Analysis:

WBS (Work Breakdown Structure):

At this stage, WBS developed by engineers of the project are dealt with, and then the data is entered into Pert Master software.

Setting relationships and dates:

At this stage, according to the duration of the activities, start and end dates of activities, and relationships between activities, outline of the project was completed. Then data was entered into Pert Master software.

Entry of data determined by qualitative analysis:

At this point, the risks associated with each activity, according to the qualitative analysis carried out from previous stage, enter the software, so that risk factors are linked with activities and finally time risk of activities is extracted, then time-cost risks are determined. In more detail, which means that all known risks, identified in the previous stage, are assigned to individual activities. Obviously, some activities get more than one risk, then based on the average risk

assigned, software determines the time distribution function and the cost of activity, and based on Monte Carlo simulation, the time and cost of the project are determined.

Determining the distribution function that can be used in quantitative risk analysis:

Stats distribution of activities time is triangular distribution in this distribution activity duration are entered the software in three modes of optimistic, probable, and pessimistic the numbers are obtained based on description above.

Triangular distribution:

The spectrum of the distribution is Triangle (min, most likely, max).

This distribution is one of the mostly used distributions in modeling risk. This distribution is often used to model the time and cost of an activity. The simple parameter of this distribution makes its connection with the real world simple. This distribution requires time, minimum, maximum, and likely, to model risk of projects usually triangular distribution skewed to right is used.

This is because most activities cannot be completed before a specific time, but all activities can be delayed for various reasons. This makes the minimum time period be closer to the maximum time than to likely time.

Finally, this distribution can easily simulate the real world based on the available parameters.

It should be noted that there were other distributions available for modeling including:

Distribution of Beta Pert, even distribution, cumulative distribution, discrete distribution, widespread distribution, public distribution normal distribution, log-normal distribution, triangular distribution Trigeen

Monte Carlo modeling:

Monte Carlo uses a set of mathematical methods for mathematical description of the impact of risk and uncertainty on an issue of interest. In this method, any non-deterministic factor can be expressed by a probability distribution function. The shape and size of this distribution determines the values of certain parameters that a certain probability can assume.

Monte Carlo risk analysis software then randomly selects the probability distribution of values and repeats it hundreds or thousands of times. The calculated values for exits, for each iteration (scenario) are stored. In the end, simulation of the output values registered in order to assess uncertainty in model output are analyzed. The results of Monte Carlo simulation are the output probability distribution, descriptive statistics related and the relationship between inputs, outputs and uncertainty.

RESULTS

After defining business processes, and making adjustments related to date and time of each activity, defining the cost of each activity, specifying the activities prerequisite for any activity, defining risks of previous stage in software, the relationship between risks and activities and determining the triangular distribution parameters, we started to perform Monte Carlo simulations using software. The software did this 1,000 times, the results of the three remaining period (not total duration) and the remaining costs and final date were obtained using different percentage of confidence.

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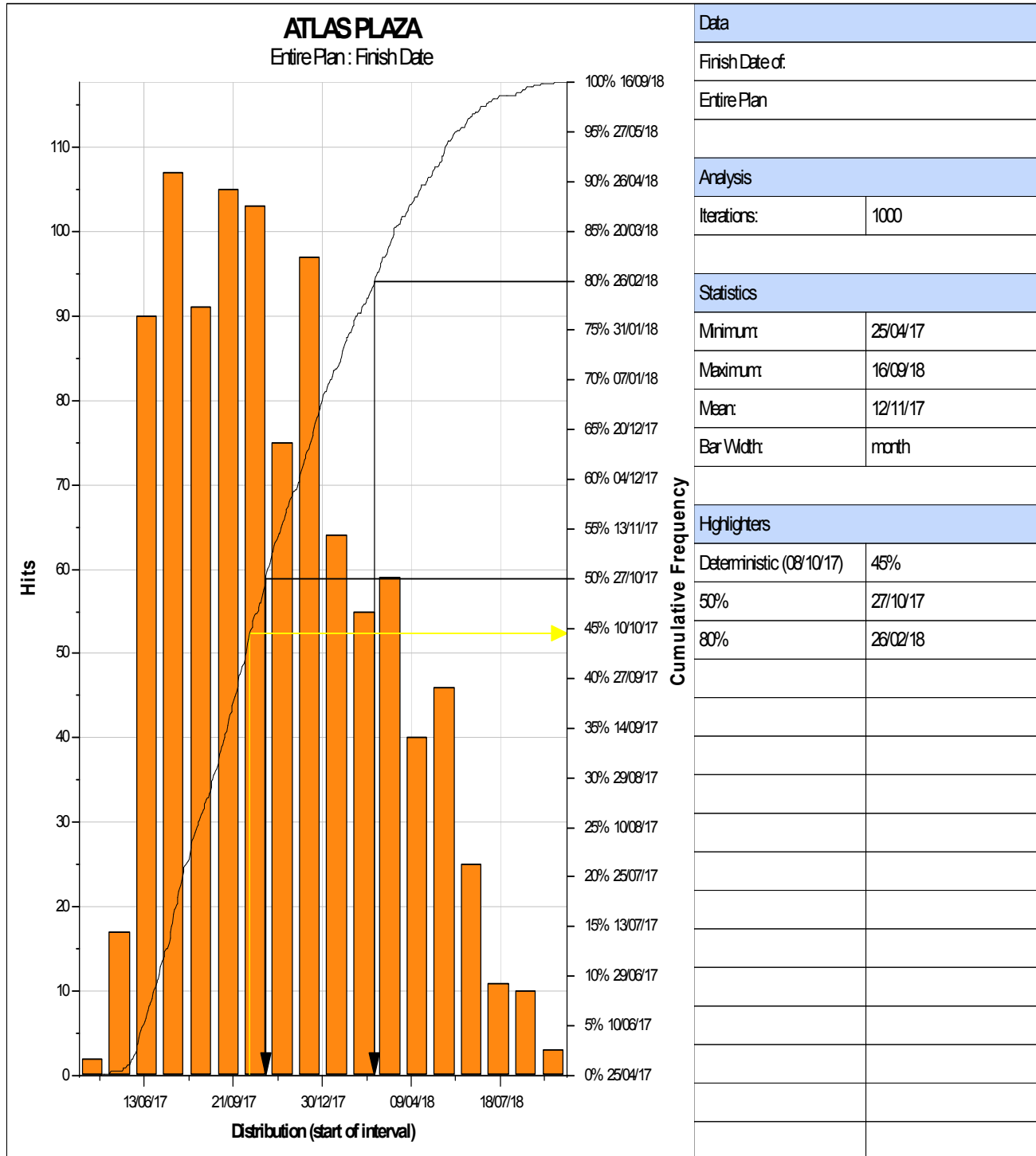


Figure 2: Monte Carlo simulation output (the end)

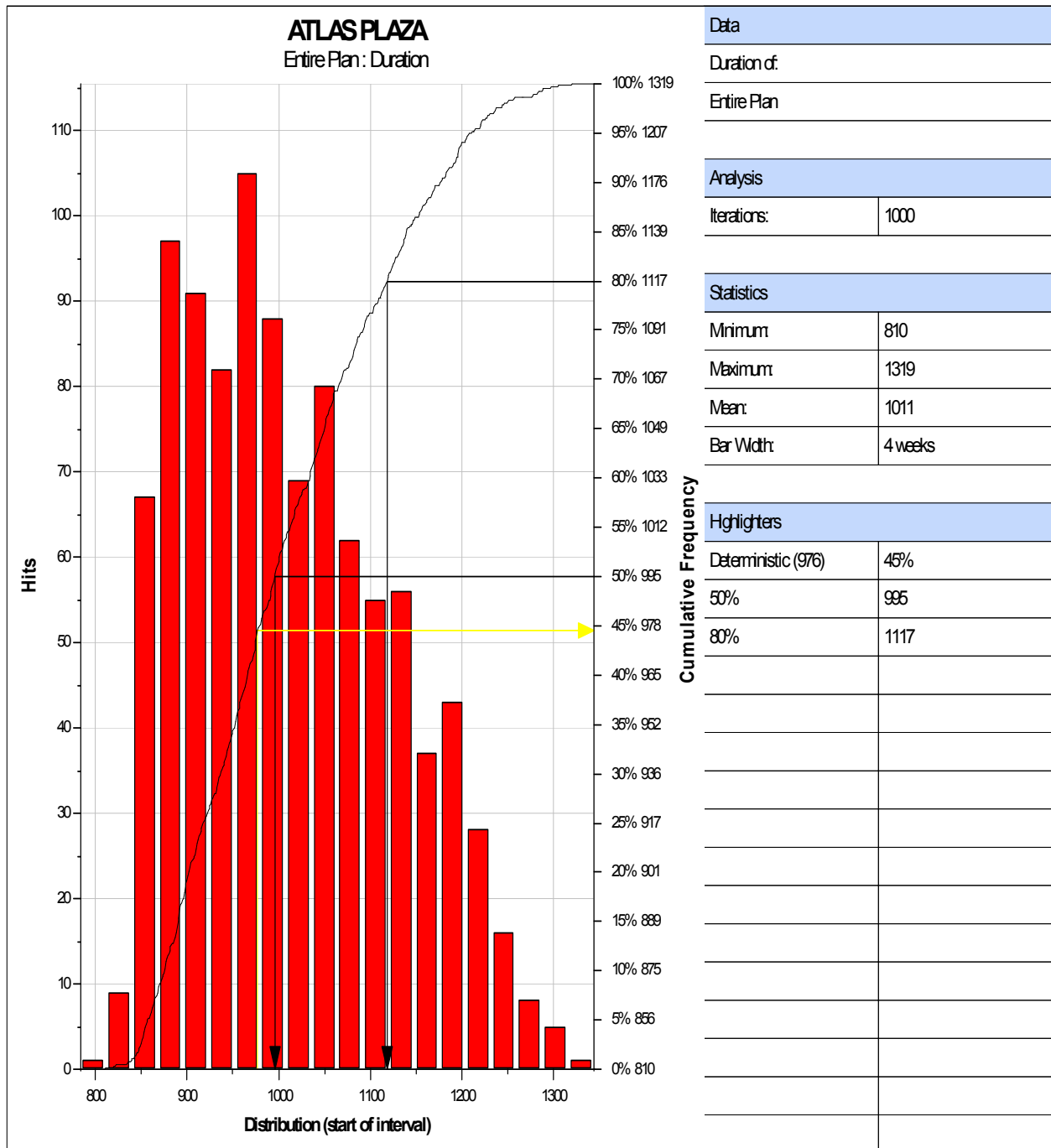


Figure 3: Monte Carlo simulation output (Short time)

Viewing project profile before and after the simulation is not unpleasant:

Table 4: summary of the status of the projects

Solar	AD	Billion Rial	Day	
1390/07/17	24/08/2011			start date
1396/07/17	8/10/2017			The initial completion date
1396/11/03	20/02/2018			Completion date simulated by risk
		6690		The remaining initial costs (billion Rial)
		7930		Price Simulated with risk
		8500		Initial total cost
		9740		The total cost simulated
			976	The initial period remaining
			1117	The remaining duration simulated with risk
			2239	The initial period
			2380	Total period simulated by risk

3.5. Developing the program to response to risks:

At this stage, measures to enhance opportunities and reduce threats to achieve project goals are determined. For the plan to respond to risk, one of the strategies of risk avoidance, risk reduction, risk transfer, risk-taking are used. In order to determine the strategy used for each risk, stakeholders of the project attended a meeting, where it was determined that the risks whose value is above 35% are known as critical risks and require a response

Definitions:

Avoidance: the base of work of avoidance strategies is to find alternative solutions in a manner that is less risky

Transfer: This solution is used for group projects and has the responsibilities to send risk outside the organization.

Reduction: this includes the event handler so that the impact and risk of injury reduce.

Acceptance: This strategy is chosen when limitation and variables of project are outside the control risk projects and the impact of the project should be about tolerance defined on project objectives.

Table 5: Response to Risk

Row	Factors studied	Response strategy
1	Lack of appropriate financing of HSE unit	Avoidance
2	Lack of safety culture in the workplace	Avoidance
3	Lack of establishing HSE management system requirements	Avoidance
4	The lack of detailed mapping calculations of excavation and drilling	Decrease
5	Lack of safety in the demolition of (excavation)	Decrease
6	Writing contracts, regardless of the level of project risk	Avoidance
7	Lack of safety in excavation	Decrease
8	Failure to observe basic safety principles and the absence of electricity proper earthing system	Decrease
9	Failure to define minimum requirements for HSE management of contractors in general terms and specific Treaty	Avoidance
10	Lack of safety in wells and drilling and pile	Decrease
11	Lack of proper placement facilities	Decrease
12	Lack of planning HSE management system by contractor in pre-contract	Avoidance
13	Lack of maintenance and inspection of tower crane and lift	Decrease

3.6. Monitoring risks:

In risk management meeting, it was decided that every 3 months after that, all the risks are updated, processes repeated, and documentation stored.

4. Conclusion

- ☐ Safety risks, will add 14 percent to the cost of the entire project to 80 percent likelihood.
- ☐ Safety risks, will add 6 percent to the time of the entire project to 80 percent likelihood.
- ☐ Prioritizing safety risks affecting projects.

According to PERTMASTER software output, it became clear that the safety risks in construction projects would have a positive impact on the total cost of the project, and with probably of 80%, these costs would increase by 14 percent in the whole project, which would be considerable. According to Table 4, which is extracted from a simulation process with a possibility percentage of 80%, the overall costs have been estimated at 8500 billion Rials, and, based on risks, that is around 9640 billion Rials within the simulated process. 9740 divided by 8500 is 1.14, which suggests that the risks have added a total of 14% to the overall costs.

Furthermore, again, based on Table 4, the overall time required to accomplish the project is 2239 days, which goes as up as 2380 in accordance with the current risks and the simulation process. Thus, 2380 divided by 2239 is 1.06, which shows that 6% has been added to the overall time required for the project. Therefore, according to the above two components, it can be concluded that safety risks and identifying and considering them in development projects is essential to prevent the imposition of exorbitant fees and waste of time. Notably, during the study prioritizing safety risks affecting the construction were determined and a standard questionnaire was obtained that can be used in other construction projects.

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