Managing Project Delays: Simulation-Based Methodology for Project Scheduling

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Abstract

The aim of this paper is to recommend proactive actions to avoid disruption in achieving project objectives, in particular to meet project deadlines. A case study was conducted on an ongoing project in Kuwait (which is Al-Ghouse Road) in order to avoid potential schedule delays. The originality of this approach is the ability to detect crucial activities and events that might delay projects but are not detected by classical techniques. It the beginning, high-level actions were recommended by applying a project risk management process in compliance with the Project Management Institute (PMI) recommendations. After identifying the risks at the high level, the project schedule was analyzed using Monte Carlo Simulation, by taking into account the uncertainties in the estimation of activities durations. This helps in identifying crucial project tasks with high uncertainty and deliverables that might delay the whole project but not identified by the Critical Path Method. Different professional software were used: "RiskyProject", "Primavera" and "MS Project".

Keywords
Project Risk Management, Project Delays, Project Scheduling, Monte Carlo Simulation

1. Introduction

Project Risk Management is defined as the systematic process of recognizing, evaluating, and replying to risk as a related task to the project, or decision-making behaviour that is not known in advance, but influences the project goal. Risk management refers to optimizing and improving the decision to reduce the lack of confidence about the future events when the information is incomplete, unclear or under decision (Institute of Risk Management (IRM), 2011). Studies carried out by Bourn (2003) show that 70% of UK construction projects carried out by public departments and agencies are delayed. Many delays occurred in several construction projects, which highlights the importance of this study. Risk management procedures should be followed and implemented within ongoing projects, to improve project success rate. It is necessary to manage scheduling risks, which are events or unclear situations that may impact the completion time of the project (Hillson D. , 2002). To overcome the problem, it is essential to determine the causes and effects of the delay to avoid it as much as possible. In Al-Ghouse Road, a proactive approach will be applied to prevent the risk before it occurs. On the other hand, if any risk occurs a corrective action will be applied to avoid any delay in the project. The Project Management Institute (PMI) has addressed this dual perspective of overall risks and individual risks in the Practice Standard for Project Risk Management (PMI, 2009). The standards of Project Management Institute (PMI) will be followed to manage the risks that may delay the project. The originality of this research paper that it detects crucial tasks with high delay risks, but they are not detected by classical techniques i.e. critical path method. The methodology that is related to the Al-Ghouse Road Project consist of: risk identification, risk assessment, risk responses, and monitor and control.

2. Background

Al-Ghouse Road has been under construction and improvements since 2016, it starts from Sabah AL Salem city till Al-Thahar. This project aims to increase the efficiency of this road to serve the residential areas to fit with the

current capacity increase of the road network of the residential areas located on the side of this road. Moreover, it aims to reduce the traffic congestion on Fahaheel fast road and the main roads with it. Al-Ghouse Road will be developed from north Bayan area and intersect with Fifth Ring Road and along Fahaheel Highway to Sixth Ring Road. The length of the road is 7 km in addition to the sub-roads. The financial cost for the whole project is more than 10,000,000 KWD and the companies estimated completion duration is due Dec 6,2019. This study was done during the project progress. The project owner is Public Authority for Roads and Land Transport. The company responsible for this project is the Combined Group Contracting Company. This ongoing project is complex with many stakeholders.

3. Literature Review

Many research articles exist about causes of delays, since many companies have faced it in different countries. This part will be discussing the issue that can cause a delay and how to control this delay and detect it. Moreover, having proactive approach helps in preventing any delay before occurring. Proactive approach is a strategy that help in controlling the time to reach the planned schedule. For this project, two level analysis was applied. A high level analysis which follows the classical risk management procedure. Then a low level analysis was applied on the project schedule using Monte Carlo Simulation to identify crucial activities that may delay the project. This method provides accurate insights and actions to help project team members to identify and treat crucial tasks and critical risks. Many studies will be discussed to prove these facts.

3.1 Causes of Delays

(Mohamed, 2015), discovered the most important causes that lead to project delay in building construction projects in Sudan. The case study was about construction Khartoum International Airport in Sudan. The expected time to complete the Khartoum International Airport construction was planned for 2003 and the total cost $1.8 billion. This new airport was designed and constructed to serve over 6.5million travelers a year. Unfortunately, the construction of the airport has been delayed around one year. In addition, the government could not raise adequate money through the split and wastage of large oils field at the boundaries that influenced the economy. They also indicated the most significant risks of building construction delays were found to be; excessive pressure on project stakeholder, material pricing and overall project inflation, disputes between project participants, project abandonment, overall cost increase and revenue decrease.

Other studies also show how the construction delays causing risks. Ramanathan, Narayanan, and Idrus, “Construction Delays Causing Risks on Time and Cost - a Critical Review.” conducted a study of the building projects nowadays and how it is faced problems in delaying the plan and schedule of the construction project. This delay can lead to exceeding the initial time and cost budget. There are 113 causes for having this delay which are categorized into 18 different groups. These groups are: finance- related, project-related, project attributes, owner/client, contractor, consultant, design-related, coordination, materials, plant/equipment, labor/manpower, environment, contract-related, contractual relationships, external, changes, scheduling & controlling and finally, governmental relationship. In this study, they ranked these groups based on doing questionnaire surveys by collecting the answers from a random sample. After collecting the data and analyzing them, the results was: rank one is Owner, rank two is Contractor, rank three is Design related and Plant and Equipment, rank four is Labor, and rank five is Consultant and Contractual relationships. Therefore; it’s shown that country, location, and project specific are the general and main factors that cause delays. On the other hand; there is no general or root causes for this delay.

Mahamid, Al-ghonamy, and Aichouni, “Risk Matrix for Delay Causes in Construction Projects in Saudi Arabia.” conducted a study of the risk matrix for delay causes in the construction projects in Saudi Arabia. Since, the time performance is the most important thing in construction projects, but there are two difficult construction issues in any project which are: delay and failure to complete the work in a specific time. In this study, the risk is identified by making a questionnaire survey for the consultants who’s working on the construction projects in Saudi Arabia. They did this survey for 51 consultants, and they found out from their viewpoints that the top delay causes are: bid award for lowest price, changes in material types and specifications during construction, contract management, duration of contract period, fluctuation of prices of materials, frequent changes in design, improper planning, inflationary pressure, lack of adequate manpower, long period between design and time of implementation, payments delay, poor labor productivity and rework. After analyzing the data collected from the survey, it shown that there is a good reliability and agreement between the respondents and the occurrence of these delay causes which are identified.

Soliman, "Recommendations to Mitigate Delay Causes in Kuwait Construction Projects." suggested a set of recommendations to mitigate the influence of delays in Kuwait's construction projects. Top causes are examined and analyzed to determine why these high - level delay causes occur and how they can be prevented or mitigated in the event of an occurrence. Top-ranked delay causes can be categorized into five groups:

1) Problems associated with contractual and governmental procedures.

2) Problem associated to local construction industry.

3) Problems associated to project management.

4) Problems associated to finance.

5) Problems associated to the procedures of planning and control, and skills.

They found out that the contractual and governmental related problems are delay in preparation and approval of different orders, changed conditions of engineering from the contract document, making decisions slowly, risk distribution especially on the contractors, and delay in government approvals. American journal of Civil Engineering and Architecture (2017) found "The projects that experienced variation orders incurred more than 58%-time delay and cost increases when compared to those with no variation orders ". Moreover, many recommendations have been suggested to control consequences and risks of changing order in construction industry. Charoenngam et al suggested "a web-based change order management system that supports documentation, communication and integration between different team members in the change order workflow to manage change order procedure". Halwatura and Ranasinghe proposed that "increasing communication channels and hire professional planning staff would reduce occurrence of changing orders in projects". SCPD report recommended "accelerating process of agencies approval by changing and fast-tracking documentation cycle for getting approval and revision for new projects". The second group which involves local construction industry related problems that contains several delays causes such as: decreased productivity of labor, availability of material, equipment, and labor, technical staff shortage, and varying level of productivity. Ehab Soliman (2017) mentioned that "To solve this problem, there are two recommendations. It is recommended to change labor supply procedure from abroad especially for big or mega projects. It is also recommended to establish educational and training centres to qualify labor force to enter Kuwaiti construction industry ". The third group of the top-ranked delay causes is project management skills related problem which are: inadequate experience for the contractor, limited supervisory authority, subcontractor coordination, defective design, lack of coordination of design drawings, disagreement between contractor and consultant. To mitigate these problems, Ehab Soliman recommend in his article "to review and revise project-awarding system used in Kuwait especially in large governmental projects. Changing awarding system may mitigate problems of using lowest price strategy ". The fourth group is related to the financial problems such as: contractor financial problems, failure of finance, financial problems for the owner, delaying payments from the owner to the contractor. However, it is recommended that the project award procedure be revised to ensure that the contractor has adequate financial capacity to finance the project and it is suggested to change general condition document by adding a penalty clause for delaying payments. The last group is project planning and control skills related problems. The causes of delay for this group are: unrealistic periods for design development, lack of CPM planning and use, lack of planning and control on the subcontractors ' side, poor subcontractor scheduling. To reduce these causes Kuwaiti governmental general contract (2003) clause 14 stats that: "it is essential for contractor to submit project program prior to project start. In clause 46, which is regarding work progress stated that: "The contractor has to accelerate his work progress if the work is delayed. These clauses lack of defining time frame to submit project original program". Moreover, it is extremely important for all project parties to improve their planning and control skills. Also, defining prerequisites for project planners such as experience, working in similar projects, with adequate educational and technical skills for project monitoring is recommended to mitigate delay causes.

Table 1, represents the causes of delay that any project may face. There are many numerous reasons that may cause delay. In order to control the impact of this delay, the causes must be defined.

Table 1. Causes of Delays

Title	Causes of project delay	References
Delay Causes in Iran gas Pipeline Projects.	-Imported materials. -Realistic project duration. -Client-related materials. -Land expropriation. -Change Order. -Contractor selection methods. -Payment contractor. -Obtaining permits. -Suppliers. -Contractor's cash flow.	Fallahnejad, "Delay Causes in Iran Gas Pipeline Projects."
A framework for Identifying Caused Factors of delay in Nuclear power plant projects.	-Missing schedule updates. -Design errors. -Scope change.	Alsharif and Karatas, "A Framework for Identifying Causal Factors of Delay in Nuclear Power Plant Projects."
The causes and effect of delay in Pakistan.	-Finance and payments. -Inaccurate time estimation. -Quality of material. -Delay in payments to supplier and subcontractor. -Poor site management. -Old technology. -Natural disasters. -Unforeseen site conditions. -Shortage of material. -Delays caused by subcontractors. -Changes in drawings. -Improper equipment. -Inaccurate cost estimation. -Change orders. -Organizational changes and Regulatory changes.	Haseeb et al., "Causes and Effects of Delays in Large Construction Projects of Pakistan."
Delay in the Construction of Public Utility Projects in Saudi Arabia.	-Owner participation. -Worker performance. -Early planning and design of the project. financial problem.	Al-Ghafly, "Delay in the Construction of Public Utility Projects in Saudi Arabia."
Exploring delay causes of road construction projects in Egypt.	-Political situations. -Split of the west bank and limited movements between areas. -Prize project to lowest bid price. -Development payment delay by owner. -Shortage of equipment.	Aziz and Abdel-Hakam, "Exploring Delay Causes of Road Construction Projects in Egypt."
Time Delay and Cost Overrun in Qatari Public Construction Projects.	-Extensive and poorly managed changes.	Senouci, Ismail, and Eldin, "Time Delay and Cost Overrun in Qatari Public Construction Projects."

3.2 Proactive Approach

"According to the Chaos Report in the years 2002-2012 [Standish Group 2013] around 80% of IT projects were late". In this study two approach were used. First, proactive approach applied before the project begins its about having initial schedule that support the plan in order to avoid any issue that may occur and delay the project. Nevertheless, initial schedule never stables because some disturbance may change the duration. Second, reactive

scheduling applied after the issue is occurs to control the schedule in a way of keep focusing on the goals. While starting the project some external situations may appear during the project that will expand the planned processing time. Buffers may be used to store the extra time of the planned schedule. If the project completion moment is the most important moment the buffers are placed at the end of tasks sequences. On the other hand, the buffers placed after each activity if the completion times of individual activities are important. Only the project manager knows about the buffer size and presence. The buffer size depends on the characteristics of the project activities and its related information. The reactive scheduling is to make the buffer flexible in order to adapts with any changes. The two approaches are rarely used which is a clear reason of having delays in almost all projects. In proactive approach; the author of this study suggest to follow the previous approaches that mention before, starting from zero and define all of: project tasks, original duration, the dependencies between the tasks. End up with the project network. Applying extra tasks in order to define the scope properly. In reactive scheduling; project controlled and schedule update must be absolute. Both the author and project team are responsible to expect the critical aspect and re-describe it if needed. After applying these approaches, the project was under control and completed with the planned duration. Moreover, proactive approach and reactive scheduling are important combination to prevent any delay during the project. This combination helps in recognize the factors that may have impact on the project and correct the work (Naukowi, Dudycz, & Brycz, 2015).

3.3 Monte Carlo Simulation

Monte Carlo Simulation is a mathematical technique that assume random variables to justify any risk that may happen. Usmani, "What Is a Monte Carlo Simulation?" mentioned that Monte Carlo could be a scientific strategy that permits you to account for risks in your decision-making process. With the assistance of this strategy, managers will be able to decide the impact of the recognized dangers by running simulations numerous times and distinguish a run of conceivable results in a completely different scenario. In addition, the author said that the entrepreneurs can use Monte Carlo simulation to analyze the effect of risk on forecasting models such as cost, and schedule estimation as this method will facilitate the process and make it more accurate and relevant especially in these types of decisions, where there is certain degree of uncertainty and the result will not be correct without this model.

(RiskAMP, 2005) made a study about Monte Carlo simulation and solved an example about it. The example was about estimating how much time it will take to finish a construction project that have three tasks. To know the total time, a single estimate for each task of the project have been created and the models gives a result of 14 months as a total time to finish the project. Although the result was obtained, but it wasn't convenience since this model did not mentioned anything about the risk that may happen. Therefore, Monte Carlo simulation have been applied, it starts by estimating the minimum, most likely, and maximum for each task and from these estimations, the range of the possible outcomes have been defined which was between 11 and 19 months. After that, Monte Carlo simulation, creates random variables for each task and calculate the total completion time and the simulation was run 500 times. In the first model the completion time was 14 months, but in Monte Carlo simulation the time will be more accurate. Monte Carlo simulation gives a result of only 34% chance that any individual trial will result in a total time of 14 months or less and 79% chance that the project will be completed within 15 months. It appears that the completion tome will fall between the minimum or maximum total values.

4. Methodology

In this paper, risk management process will be applied in order to help manage all the risks that are required to avoid any delay. Risk is an uncertain event or condition that if it occurs, it will influence at least one project objective. Focusing on managing Al-Ghouse Road Project to avoid delays by applying a Project Risk Management Methodology in compliance with the Project Management Institute (PMI) recommendations. This methodology has two levels: high and low level. High level of risk management process includes four steps, which are: risk identification, risk assessment, risk responses, and monitor and control. Low level highlights the crucial tasks that need monitor and control. In this project, both levels will be obtained. Risk management on the high level and apply monitor and control on the crucial tasks that may delay the project in low level.

4.1 Risk Identification

Risk identification is the process of listing potential project risks. There are many risks that may occur during Al-Ghouse Road Construction Project. The risks have been identified by applying some techniques and tools for instance: brainstorming; which is done by generating all possible ideas from the group members, interviewing; which is conducted with Al-Ghouse Road Project team members, and checklist of risk categories; which is used to come up with additional risks for the project. After using these techniques and tools we reached to 21 risks as shown below in table 2.

Table 2. Risk Identification

Risk Identification	
1. Project delays.	2. Late in order the needed materials for the project.
3. Lack of employees and materials.	4. Supply materials that are non-conforming to the specifications.
5. Poor communication between the site and head office.	6. Late in bills payment.
7. Noncompliance to required quantities, specifications, drawings and plans.	8. Losing control in the cash flow.
9. Differences between actual and contractual quantities.	10. Legal disputes between the company and the neighbors.
11. Changes in design.	12. Difficulties in getting licenses and permits.
13. Delays and technical problems between subcontractors.	14. Lack of understanding in some of working rules and plans.
15. Unqualified employees.	16. Weather conditions impact.
17. Internal conflicts between team members.	18. Difficulty in reaching the site.
19. Lack of safety.	20. Lack of security and thefts.
21. Fluctuation of machines' productivity rates.	

4.2 Risk Assessment

After the potential risks have been identified, the group members evaluate the risk based on the probability that the risk will occur, and the impact associated with the risk. This evaluation was done by risk assessment matrix, which is used to define the level of risk by considering the category of probability against the category of severity of

the impact. The matrix is divided into five categories for both probability and impact which are very low (0-20%), low (21-41%), medium (42-62%), high (63- 83%), very high (84-100%) as shown in table 3.

Table 3. Risk matrix - Assessment scale

	Probability				
Impact	Very Low 0-20%	Low 21-41%	Medium 42-62%	High 63-83%	Very High 84-100%
Very High 0-20%	**Low**	**Medium**	**High**	**Very High**	**Very High**
High 21-41%	**Low**	**Medium**	**Medium**	**High**	**Very High**
Medium 42-62%	**Low**	**Low**	**Medium**	**Medium**	**High**
Low 63-83%	**Very Low**	**Low**	**Low**	**Medium**	**Medium**
Very Low 84-100%	**Very Low**	**Very Low**	**Low**	**Low**	**Low**

However, the result of multiplying the probability and impact for each risk is criticality. Criticality helps in determining which risk need to be more focused on. Table 4, shows the criticality of each risk in Al-Ghouse Road Project.

Table 4. Risk matrix –Identify risk severity

	Probability				
Impact	Very Low 0-20%	Low 21-41%	Medium 42-62%	High 63-83%	Very High 84-100%
Very High 0-20%	**1, 12**	**2, 13, 14, 15**	**6, 7, 10, 19**		
High 21-41%		**9, 11, 16, 21**	**3**		
Medium 42-62%	**8, 17**	**4, 5**	**18, 20**		
Low 63-83%					
Very Low 84-100%					

4.3 Risk Responses

Risk responses are strategies which help enhancing appropriates or reducing the threats that may occur in the project. Risk Response is the process of controlling the identified risks. It is a basic step in any risk management process. Risk response is a planning and decision making process whereby stakeholders decide how to deal with each risk. In this paper, the strategies that helped to deal with risks are avoid risk strategy, transfer risk strategy and mitigate the causes or the consequences of the risks. Furthermore, response strategy and treatment action were defined for each risk. The following are the basic types of risk response.

1- Risk Avoiding Strategy

Avoiding risk means stopping it from happening totally. For example, changing the project design is a risk but we can avoid it by define the plan and the design clearly before starting the project. That is an example of avoiding a risk completely were you put a plan in place to make sure that it could never occur.

2- Risk Transferring Strategy

Transferring a risk means shifting the responsibility of risk to someone else. The best example of this is the insurance policy. When you buy an insurance policy, you shift some of the impact of the risk to the insurance firm, and they would be liable if the risk did happen.

3- Risk Mitigating Strategy

Mitigation is probably the most common risk response strategy. It is where you come up with actions to reduce the impact of the risk if it happens. Mitigating Strategy have two types which are mitigating causes and mitigating consequences. An example of mitigating causes is the risk of having a poor communication between the site and head office where we can mitigate the cause by increase communication channels between the site and the main office like e-mail, fax and meetings periodically. For mitigating consequences, we can take the risk of having unqualified employees as an example and we can response to this risk by mitigating consequences by having a work train courses to increase the experience of the employees.

4- Risk Accepting Strategy

The final option for dealing with a negative risk is to simply accept it. Sometimes problems happen, and you have analyzed the problem and decided that you are not going to do anything about it.

4.4 Monitoring and Controlling

Monitoring and controlling the project schedule means tracking the actual performance and compare it with the planned project activities in order to reduce the variation between them. Moreover, compared the collected information about the project schedule with the project plan and analyzed them, and developed proactive action plans and corrective action plans if needed. The key benefits of this process is that it allows stakeholders to understand the current state of the project, the steps taken, budget, schedule, and scope forecasts.

Figure 1, shows the management by deliverables. Management by deliverables has three dimensions: cost control, quality control and scheduling control. Milestones are points in time to control progress. At each milestone we synchronize the project team members and we create an effective action plan to make the deliverables meet their intended timeline, cost and quality on the following milestone.

Figure 1. Crucial activities montiroing and each project milestone

5. Simulation

After identifying the risks at high level, low level will be obtained by focusing on highlighting the important tasks that may delay the project. The classical technique to analyses delay is Critical Path Method (CPM). CPM is defined as the longest path through the project network. However, if we focus our attention only on the critical path, we may have another noncritical path becomes critical and the project will be delayed since we have uncertainty in estimated duration. Therefore, to deal with this problem we will apply Monte Carlo Simulation to highlight the most crucial activities to do a risk treatment action. Monte Carlo Simulation test a lot of posibilities before giving the result. Each activity have three estimated durations which are most optimistic, most likely, and most pesimistic. For each path there are numarous activities, and Monte Carlo Simulation examine randomly the duration for each activity. The number of simulation is estimated, the higher the number of simulation, the more accurate results will be obtained.

Monte Carlo Simulatiom calculate the results over and over, and gives different senarios each time using different set of random values from the probability function. Monte Carlo Simulation will be applied using RiskyProject Software.

To start the simulation of Al-Ghouse Road, all the activity information's were listed in the software as shown in figure 2. The activity information's are activity ID, most optimistic (low) duration, most likely (base) duration, most pessimistic (high) duration, start time, finish time, and Immediate Predecessor (IP), in the project view from schedule. The most optimistic and pessimistic durations are estimated randomly in order to get the most uncertainty activities that may become critical during the project.

	Task Name	Low Dur	Base Dur	High Dur	Risks	Start	Finish	Predecessors
1	CA1R0-ALLG-00.00/000	17.6 days	22 days	24.2 days	0	05/08/19 08:00	06/06/19 17:00	17,11,12,3,14,9,16,2,15,8,4,6,7,10,13,5,25,26
2	CA1R0-ALLG-07.18/010	2 days	5 days	5.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
3	CA1R0-ALLG-07.18/020	3 days	5 days	7.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
4	CA1R0-ALLG-07.18/040	4 days	5 days	6.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
5	CA1R0-ALLG-07.18/050	4 days	5 days	10.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
6	CA1R0-ALLG-07.18/070	3 days	5 days	6.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
7	CA1R0-ALLG-07.18/080	4 days	5 days	6.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
8	CA1R0-ALLG-07.18/110	4 days	5 days	9.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
9	CA1R0-ALLG-07.18/130	4 days	5 days	8.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
10	CA1R0-ALLG-07.18/140	1 day	5 days	5.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
11	CA1R0-ALLG-34.41/010	3 days	5 days	8.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
12	CA1R0-ALLG-34.41/020	2 days	5 days	9.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
13	CA1R0-ALLG-34.41/030	3 days	5 days	10.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
14	CA1R0-ALLG-34.41/040	2 days	5 days	7.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
15	CA1R0-ALLG-34.41/050	2 days	5 days	8.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
16	CA1R0-ALLG-34.41/060	4 days	5 days	7.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
17	CA1R0-ALLG-34.41/070	3 days	5 days	5.5 days	0	05/01/19 08:00	05/07/19 17:00	20,24
18	CA1R0-ALLG-35.41/000	0 days	0 days	0 days	0	06/06/19 17:00	06/06/19 17:00	17,11,12,3,14,9,16,2,15,8,4,6,7,10,13,5,25,26,1
19	CA1R0-RA1N-32.11/122	1.6 days	2 days	4.2 days	0	04/29/19 08:00	04/30/19 17:00	
20	CA1R0-RA1N-32.11/140	2.4 days	3 days	5.3 days	0	04/29/19 08:00	05/01/19 17:00	19
21	CA1R0-RA2S-32.11/110	3 days	5 days	6.5 days	0	04/23/19 08:00	04/29/19 17:00	22
22	CA1R0-RA2S-32.11/121	1 day	5 days	8.5 days	0	04/23/19 08:00	04/29/19 17:00	
23	CA1R0-RA2S-32.11/122	2.4 days	3 days	4.3 days	0	04/29/19 08:00	05/01/19 17:00	21

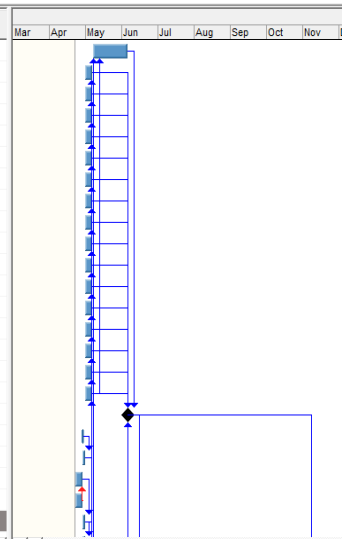


Figure 2. An example of activities of AlGhouse Road project

After inserting the data, the simulation was runed 10000 times. Figure 3, shows the result of Monte Carlo Simulation on the project; the probability was 80% to finish the project in a duration less than 172.32 days.

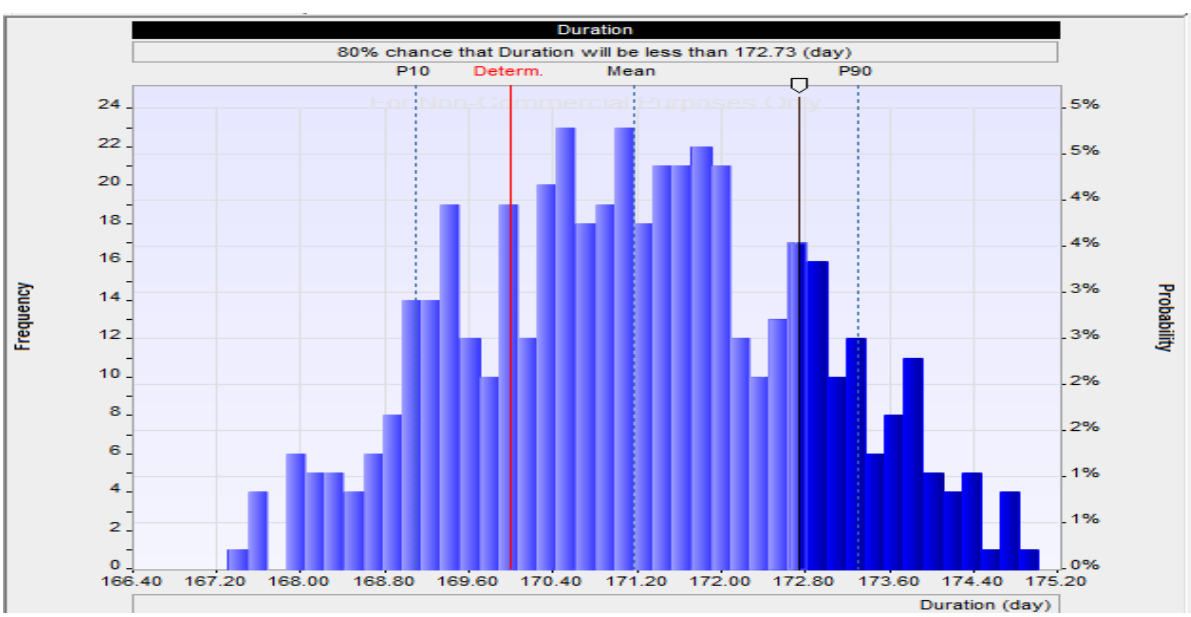


Figure 3. Monte Carlo Simulation Result

Figure 4 also shows a Monte Carlo Simulation Result but in more obvious way. The result shows that the project have a probability of 81% to finish the Road in Dec 18,2019.

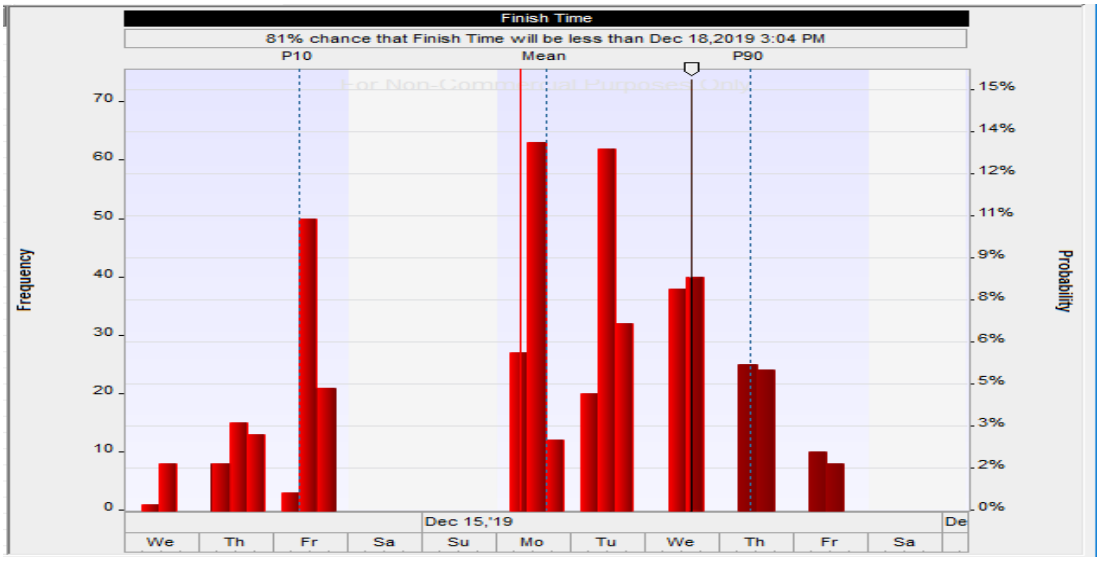
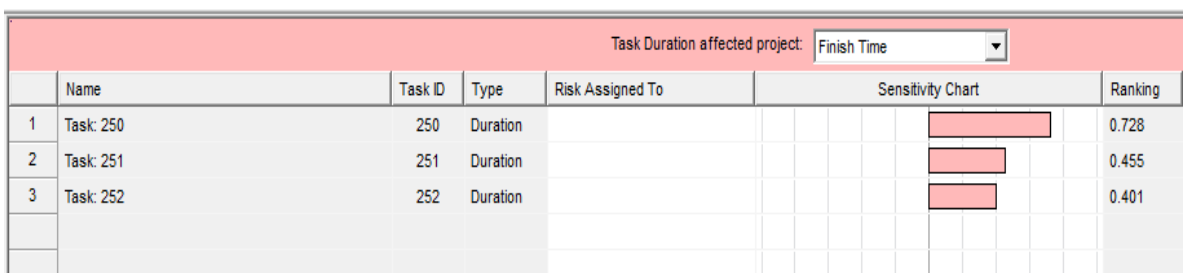


Figure 4. Monte Carlo Simulation Result

To determine the most crucial activities, sensitivity analysis is obtained and the result was as shown in figure 5. The analysis shows that the crucial activities are 250, 251, and 252. Moreover, it shows that activity 250 is the most crucial since it have a ranke of 0.728.



	Name	Task ID	Type	Risk Assigned To	Sensitivity Chart	Ranking
1	Task: 250	250	Duration			0.728
2	Task: 251	251	Duration			0.455
3	Task: 252	252	Duration			0.401

Figure 5. Sensitivity Analysis

5.1 Simulation Analysis

CGC Company have their own expectations results about Al-Ghouse Road Duration. They expect that the Road will be completed in Dec 6,2019, while the simulation result shows that it will end due Dec 18,2019. According to Monte Carlo Simulation results, figure 4, Al-Ghouse Road Project will be delayed for 7 working days with a probability of 81%. The consequences of delay are not limited to days but include cost, workforce, and investigation. The importance of this simulation is to avoid any delay that may occur to the project by knowing the accurate completion duration. Moreover, it provides the company with the crucial activities that may have huge impact on the project if they delayed.

After recognized the crucial activities monitor and control have applied as a corrective action to meet the objective. Figure 6, shows the standard target and actual target of the project critical activities. Our aim is to reduce the gap between them to let the actual meet the standard target in order to avoid delays. Moreover, by reviewing the progress, we can meet the performance objectives of the project management plan.

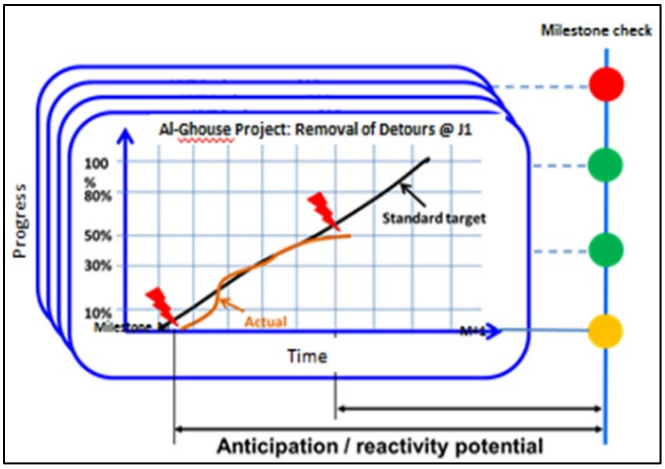


Figure 6. Monitor and Control

6. Conclusion

To sum up, proactive approach utilized to prevent any issue that may occur before the project start; by applying Project Risk Management Methodology that contain risk identification, risk assessment, risk response, and monitor and control on Al-Ghouse Road Project. Simplifying a complex data for Al-Ghouse Road Project by explain simple model thoroughly. Monte Carlo Simulation result graph gives us the accurate completion duration. The improper estimation for completion duration can affect the budget, worker, company's reputation, and planned schedule. To avoid having delays in the project, the company must focus on the duration and control the crucial tasks that may occur during the project by applying proactive approach. According to the result, Al-Ghouse Road Project well be delay for about 7 days. Al-Ghouse Road Project contain some crucial activities that have most uncertainty and may change during the process. Therefore, corrective action applied for those crucial activities by monitor and control.

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Biographies

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Hadi Jaber is an Assistant Professor at the American University of the Middle East, Kuwait. He was previously an Assistant Professor of Project Management at AUB (American University of Beirut, Lebanon) in the Department of Industrial Engineering and Management. He obtained his Ph.D. in Industrial Engineering from École Centrale Paris on March 11, 2016. He received formerly the Master's degree in systems engineering from “ENSTA Bretagne” in 2012, and the M.Sc. in industrial systems and projects from Université d'Angers, France in 2012. His professional experience includes roles as Systems Engineer at the French Atomic Energy Commission; Quality Engineer at RENAULT within the Strategy of Quality Management Department; Quality Engineer at TOTAL within the Chair "Managing Procurement Risks in Complex Projects”; and lecturer in the Industrial Engineering department at École Centrale Paris. His research focuses mainly on Project Management and Maintenance organization. He coauthored more than fifteen publications.