PROBABILITY ANALYSIS OF PROJECT SCHEDULE USING MONTE CARLO SIMULATION IN EXCEL

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Abstract: In this competitive world, with limited resources, cost and time in project management is paid increasing attention. For any kind of project, schedule is essential for successful execution of the project, so the management of schedule is very critical. It is observed that important risk about the construction schedule is time duration risk. Duration risk means the possibility and loss of incompletion of project in the stipulated duration limit. So it require to analyse the probability of each work in program evaluation and review technique [PERT]. On the basis of probability obtained from PERT analysis (Normal or Beta distribution) it simulates the project's duration and analyses the probability of construction schedule by Monte Carlo simulation method. Monte Carlo simulation method is used to simulate the duration for each activity and also the overall project to accurately determine the project completion probability under considering of the changeability and randomness of duration for each activity.

Index terms – PERT, Normal or Beta distribution, Monte Carlo Simulation.

1. INTRODUCTION

1.1 GENERAL

Construction projects are with many unique features such as long duration, complicated processes used for its execution, environment in which project has to be completed, financial intensity of the project and dynamic organization structures and such organizational and technological complexity generate various risks [8]. If it is observed schedules are essential to the successful execution of projects on time. However, schedule often contain significant uncertainty because risk and uncertainty are ingrained in all construction activities. It is widely accepted that construction project schedule plays major role in project management due to its influence on success of project within stipulated duration. The uncertainty and reliability related issues are becoming more critical in engineering design and analysis, proper assessment of the probabilistic behaviour of an engineering system is important [16]. The true distribution for the system response is subject to parameter uncertainty that should be derived. However, due to the complexity of physical systems and mathematical functions, derivation of the exact solution for the probabilistic characteristics of the system response is somewhat difficult, but not impossible. In such cases, viable tool to provide numerical estimation of the stochastic features of the system response is Monte Carlo simulation (MCS). Monte Carlo simulation (MCS) is an influential technique [9]. Two important properties of Monte Carlo simulation are Simultaneous consideration of threats and opportunities, and probability of selecting various criteria. Monte Carlo simulation analysis is a statistical technique that could become as a means for risk assessors to evaluate the uncertainty. That availability has coincided with increasing dissatisfaction with the deterministic or point estimate calculations typically used in quantitative risk assessment; as a result, Monte Carlo simulation is rapidly gaining currency as the preferred method of generating probability distributions of risk.

1.2 AIM AND OBJECTIVES

Aim: To find the probability of project completion date as per the schedule using Monte Carlo simulation

Objectives:

i) To estimate the scheduled date of project completion as per the planning from experience site team and planning team.
ii) To determine minimum, maximum and average simulated date of project completion.
iii) To find the probability of estimated scheduled date.
iv) To find most probable date of project completion.

2. PROJECT SCHEDULE RISK ANALYSIS

The purpose of analysing risk is to help reduce the risk, and also to analyse what would happen in the future such that if any required decision are need be taken [1]. As risk and uncertainty are there in almost every project, therefore, project schedules often contain significant uncertainty in them, which makes scheduling even more difficult [8]. Also, since every project is unique and also conditions for every project are different so it becomes hard to accurately estimate the schedule at an early age. In such case, risk analysis and estimation of schedule are needed to be done efficiently and for this various techniques can be used [9]. To complete a project within a predefined schedule, it is essential to use proper planning tools and techniques. The two most widely used project planning & scheduling techniques PERT (Program Evaluation and Review Technique) & Monte Carlo simulation. [14].

Schedule risk analysis can help project managers identify and mitigate risks and achieve a better project outcomes. Ever since PERT was first put forward by Malcolm and successfully applied in Missile plan, PERT network is extensively used in the estimation of project duration and schedule uncertainty analysis for its simplicity [4]. However, PERT provide good approximation of risk when a project has only one path, it should not be used to analyse risk in schedules that have more than one parallel path because it underestimates the extra risk that occurs. Since almost all real projects have multiple paths, Monte Carlo simulation should be preferred analysis method. Also Monte Carlo simulation results is analysed by thousands of simulated values.

3. MONTE CARLO SIMULATION USED IN PROJECT SCHEDULE ESTIMATION

3.1 History

Simulation is used to previously understand deterministic problem, and statistical sampling was used to estimate uncertainties in the simulations. Monte Carlo simulations invert this approach, which is solving deterministic problems using probabilistic analog. In 1930 Enrico Fermi first experimented with Monte Carlo method while studying neutron diffusion but did not publish anything on it. Later it was used by Stanislaw Ulam, a mathematician in 1940s for working on Manhattan project for nuclear weapon in World war II. Further it got popularised in field of physics, Physical chemistry and operation research.

3.2 Application of Monte Carlo simulation in project risk analysis

Monte Carlo simulation (MCS), is not yet widely used in project management, it is receiving some exposure through certain project management practices. This exposure is primarily in the areas of cost of the project and time management to quantify the risk level of a project's budget or project planned completion date. Monte Carlo simulation is used in project management and explains how it helps in answering questions such as, "What is the probability of the project completion within stipulated time duration?" and, "What is the maximum probability of meeting estimated project duration?"

In time management, Monte Carlo simulation (MCS) may be applied to analysis project schedules, to quantify the confidence that project will be completed in targeted date. Project manager and experienced experts assigns a probability distribution function of duration to each task or group of tasks in the project network to get better estimated cost. A three-point estimate is usually used to simplify this type of practice, where the experts supplies the most-likely, best-case, and worst-case durations for each task or group of tasks. The experts can then assign these three estimates to a duration probability distribution, such as a Beta, normal or triangular distribution. Once the simulation is complete, it is able to report the probability of

completing the project on any particular date, which allows him/her to set a schedule reserve for the project. The above work can be easily completed using standard project management software, such as Microsoft Project or Primavera, along with Monte Carlo simulation add-ins, such as @Risk or Risk+, Ms excel.

3.3 Advantages of Monte Carlo simulation in project risk analysis

The advantage of using Monte Carlo simulation in projects is that it is an extremely powerful tool. Without the consideration of uncertainty in both project cost and schedules, the project is at risk of exceeding the project targets. Monte Carlo simulation helps in quantifying and justifying appropriate project reserves to deal with the risk activities that will occur during the project cycle. The other advantages of Monte Carlo simulation over other methods of project analysis is that it try to incorporate uncertainty. There are many analytical approaches to project scheduling; the problem with these analytical approaches was "the restrictive assumptions that they all require, making them unusable in any practical situations". The analytical methods often only provided certain moments of the project duration, instead of project duration distributions, which were much more useful in answering questions about the confidence level of project completion dates [16]. Program Evaluation and Review Technique was the previous method used for evaluating project schedule networks, but this method does not statistically account for the path convergence and therefore normally tends to underestimate project duration. Monte Carlo simulation, by actually running through hundreds or thousands of project cycles repetition handles these path convergence situations.

3.4 Limitations of Monte Carlo Simulation Applications in project risk analysis

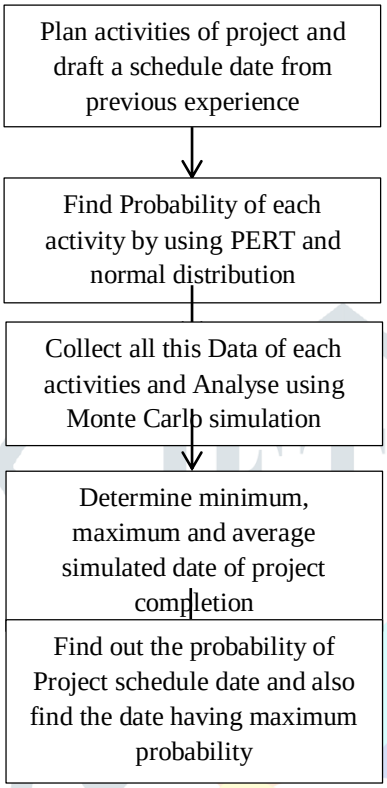
The drawbacks of Monte Carlo simulation (MCS) in the past have been use of computing power is high and the amount of time and resources spent to complete the simulation activity [16]. A lack of easy to use software tools to run complex simulation against project schedules was also a problem. Dramatic improvements in computing power and the introduction of Monte Carlo simulation (MCS) software add-ins to the popular project management scheduling tools have made these concerns virtually out of date.

Monte Carlo simulation (MCS) showing project duration distributions that are very wide is another drawback. Some of them explained that this was because "the simulations simply carry through each iteration unintelligently, assuming no management action" [16]. In the real world, it is most likely that management will take action to recover projects that are severely behind schedule, and some of these actions may help bring the project back into an acceptable schedule range. Some researchers were attempting to create models that incorporate management action into the simulation, but it is seen these models have a high level of complexity while still not incorporating sufficient generality with sufficient transparency for practitioner acceptance [16].

Although Monte Carlo simulation (MCS) is an extremely powerful tool, it is only as good as the model it simulate the information that is fed into it. If the project model or network is lagging, the simulations will not reflect real-world activities accurately. If project task duration distributions used for a project duration simulation are inadequate, the simulation will be off as well. Estimating the durations of project events normally requires expert knowledge, and even when a three-point estimate is given to incorporate uncertainty into the model, there is still some of the latent uncertainty in the three-point estimate. Previous experience and detailed data from previous projects of the same type are both useful in mitigating this estimate uncertainty, although these data are often not available.

Project schedule risk analysis in excel using Monte Carlo simulation

There are various software used for Project schedule risk analysis with Monte Carlo simulation are Microsoft Project or Primavera, along with Monte Carlo simulation add-ins, such as @Risk or Risk+, also can be done in excel. As Excel is used to with everyone and also easy to use and understand so it would feasible to use excel in it. Entire project can be divided into activities. Here activities probabilities for various conditions are analysed using PERT and normal distribution. Further this data is collected together and used for analysing the project completion probabilities by using Monte Carlo simulation in Ms Excel.



CONCLUSION

From the above study it is concluded that there are various techniques for project schedule probability analysis but everyone has its own drawbacks. It is observed that Monte Carlo simulation technique is most feasible technique so its demand for estimating project schedule risk is increasing. It was found that data used for Monte Carlo simulation was taken from previous experience data but also we can estimate the each activities probability from PERT and normal distribution. Monte Carlo simulation can be easily implemented in Ms Excel. Monte Carlo simulation can be used to determine the probability of project completion date which is estimated at site. It can also be used to find the most probable project completion date.

ACKNOWLEDGEMENT

I am very thankful to my project guide Dr. S. K Kulkarni for the opportunity given to carry out the project titled “Project Schedule Probability Analysis Using Monte Carlo Simulation in Excel” His guidance throughout year has helped me to progress in the right direction. Also, I would like to express my gratitude to Dr. S K Kulkarni HOD-Civil and Dr. L. V. Kamble Principal, D Y Patil of Institute of engineering and Technology, Ambi & those who have contributed directly and indirectly for the progress in Project Work. Finally, I would like to thank PG Coordinator (for Civil) – Himanshu Ahire for their guidance and support to complete Project.

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