

# Analysis of Factors Affecting Cost Overrun and Reducing Cost and Risk of Highway Construction Projects using Monte Carlo Simulation Methods Earned Value Management Techniques.

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**Abstract** – Cost overruns are common in all construction fields. Object of this study is to reduce risk and cost of highway construction project. Risk are identified in the planning stage by Monte Carlo simulation analysis and Earned value management. Also identify the factors affecting cost overrun, and ranking the critical factors affecting cost overrun and controlled it. Earned value management report is obtained by Primavera. Implementation of Monte Carlo simulation using Companion by Minitab. Models are creating and results show better analysis of cost overrun.

**Key Words:** Cost overrun, Factors affecting cost overrun, Monte Carlo simulation analysis, Earned value management, Risk and cost reduction.

## 1. INTRODUCTION

Kerala has narrower highways compared to other parts of India. National highway authority of India upgrades highway to a minimum four lanes, 60 meters wide, grade separated highway etc. But in Kerala national highways are being upgraded as only 45 meters wide highways. The explanations for this are difficulty and disinterest in land acquisition, Lack of facility etc. This results in the poor conditions of roads in Kerala. As a result the project costs increases day by day. This study is to predict the cost overruns in road projects by developing multiple analysis techniques like Monte Carlo simulation method and Earned value management. For doing these things effectively I would like to consider any case study from real time situations. By conducting the primary detailed observations and studies it would like to include some analytical and mathematical technics to overcome the cost overrun situations. Some preferred techniques are:

- What – If scenario analysis
- Three point estimation (Triangular and beta distribution)
- Monte – Carlo Simulation methods

Using these all, the aim is to minimize the cost of construction of public works and would like to bring some common ethics in highway projects.

### 1.1 Scope

This study aims to reduce the cost and risk of highway construction projects. First conducting a questionnaire survey and identify the major factors affecting cost overrun. And creating models and control cost and risk also control major factors. This method is useful for future projects.

### 1.2 Objectives

- Identify factors affecting cost overrun
- Develop models for reducing risk and cost of the project.
- Analysis model and implement the models into future projects.

## 2. METHODOLOGY

First step of the project is conducting questionnaire survey, Through questionnaire survey identify major factors. Second step is creating Monte Carlo simulation method and Earned value management technique. These two methods give better results about risk and cost controlling.

### 2.1 QUESTIONNAIRE SURVEY

The questionnaire survey was carried out among three groups of construction practitioners which are architects, engineers and contractors related to road construction. 50 Questions are included in questionnaire. Questionnaire survey was conducted among 35 individuals. A four point scale is adapted to ranking each question. Numerical values were assigned to the respondent's ratings. They were no effect-1, low effect-2, medium effect-3 and high effect-4.

## 2.2 RELATIVE IMPORTANCE INDEX (RII)

After survey RII method is used to ranking each question and identify major factors affecting cost overrun. RII is calculated using the equation

$$RII = \frac{\sum W}{(H \times N)}$$

Where  $\sum W$  is the total weight given to each factor by the respondents, H is the highest ranking available and N is the total number of respondents.

## 2.3 RISK MANAGEMENT BY SIMULATION TECHNIQUES

Quantitative risk analysis uses a model that simulates the combined effects of individual project risks and other sources of uncertainty to work out their potential impact on achieving project objectives. Simulations are typically worked using a Monte Carlo analysis. Simulation methods are used in Monte Carlo analysis for cost. Schedule Network diagram and duration estimates are used for tackle risk. An integrated quantitative cost-schedule risk analysis used for cost and risk schedule. The output may be a quantitative risk analysis model.

Computer software is employed to iterate the quantitative risk analysis model several times. The input values (e.g., cost estimates, duration estimates, or occurrence of probabilistic branches) are chosen at random for each iteration. Outputs gives the range of possible aspects for the project (e.g., project end date, project completion cost). Here the discussion of Simulation techniques is relies on three methods. They are:

- What -If scenario Analysis
- Earned Value Management (EVM)
- Monte Carlo Simulation techniques

## 2.4 EARNED VALUE MANAGEMENT (EVM)

Earned value analysis or Earned value management compares the performance measurement baseline to the particular schedule and value performance. EVM integrates the scope baseline with the value baseline and schedule baseline to create the performance measurement baseline. EVM develops and monitors three key dimensions for every work package and accounting system.

**Planned value:** Planned value (PV) is that the authorized budget assigned to scheduled work. It's the authorized.

**Earned value:** Earned value (EV) is a measure of work performed expressed in terms of cost.

**Actual cost:** Actual cost (AC) is the estimated cost for the work performed on an activity during particular time period.

It is the total cost planned in accomplishing the work that the EV measured.

**Forecasting:** because the project occurs, the authority may develop a forecast for the estimate at completion (EAC) this is differ from the budget at completion (BAC). If it becomes obvious that the BAC is not any longer viable, the project manager should consider the forecasted EAC. Forecasting the EAC involves making projections of conditions and events within the project's other knowledge available at the time of the forecast.

In earned value analysis, three parameters of planned value, earned value, and actual cost are often monitored and reported on both a period-by-period basis (typically weekly or monthly) and on a cumulative basis.

## 2.5 MONTE CARLO SIMULATION TECHNIQUES

To calculating the risk based on Monte Carlo simulation we can consider some set of parameters for the project schedule that planned already. Apart from the physical% of completion we can specify some parameters for project schedule and project cost. We can consider some practical based scenarios for the same:

The above matters are discussing the nature of any activities when undergone the update progress of construction projects. When we are conducting the physical% updating of the project it will give the performance of the activities like this way. But a schedule will contains lot of activities and it is not practically possible to measure each activity performance. So we should need some standard key performance index to measure the overall progress of the project. To measure such KPI values normally we are using the parameters of Earned value management especially as Schedule Performance Index (SPI) and Cost Performance Index (CPI). But it will be marked for each activities and give the summarized value for each Work Breakdown Structure (WBS). The construction projects which follows Critical Path Method (CPM), the WBS consider the performance summary of critical activities only. In such situations we can use the Monte Carlo Simulation Method to find out the uncertainties may occur in the project.

## 3. RESULTS AND DISCUSSIONS

Based on the survey report the RII value was calculated and ranking was carried out. From the data obtained the value of RII varies from 0.5 to 1 for different factors. Lack of facility and late issuing of approval documents had an RII of 1 which is ranked as 1. In Kerala compared to other states and countries construction facilities are limited because of the financial aspects and other reasons. Other major factor are late issuing of approval documents, for the government projects there may be delays for issuing documents from different authorities there by increasing the material costs and cost escalation occurs. Inaccurate time estimate and

availability of material is ranked as two since it has got an RII of 0.983. These two factors are also a major factors affecting cost overrun.

### 3.1 SCHEDULE PERFORMANCE INDEX (SPI) ANALYSIS BY MONTE CARLO SIMULATION

The schedule performance index can be taken from the Primavera case study:

Entering the CPI values in the software, then apply the Monte Carlo simulation will give the results as shown below:

Capability		Summary Statistics		Percentiles	
Specification Limits		N	1,000	0.1 <sup>st</sup>	-0.433919
USL	1.25	Mean	0.591858	0.5 <sup>th</sup>	-0.333573
LSL	0.25	Standard Deviation	0.327411	1 <sup>st</sup>	-0.220943
DPMO		Minimum	-0.433959	5 <sup>th</sup>	0.074755
>USL	21,000	Median	0.587242	10 <sup>th</sup>	0.1758
<LSL	1,47,000	Maximum	1.6715	90 <sup>th</sup>	1.0252
Observed Performance				95 <sup>th</sup>	1.1351
>USL	21			99 <sup>th</sup>	1.3437
<LSL	147			99.5 <sup>th</sup>	1.4604
	168			99.9 <sup>th</sup>	1.6715

Model Assumptions		
Inputs		
Name	Distribution	Settings
COST PARAMETERS	Normal	(0.584, 0.33)

Fig 2: CPI analysis simulation case 1

Now we are set a speculation limit of CPI from a lower specific limit (LSL) 0.75 to upper specific limit (USL) 1, then

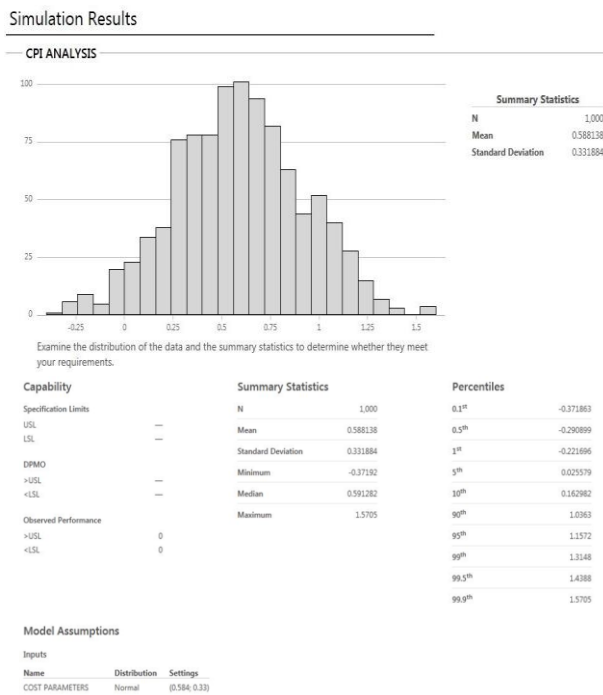


Fig 1: CPI analysis overall simulation

First of all we can set a speculation limit of CPI from a lower specific limit (LSL) 0.25 to upper specific limit (USL) 1.25,

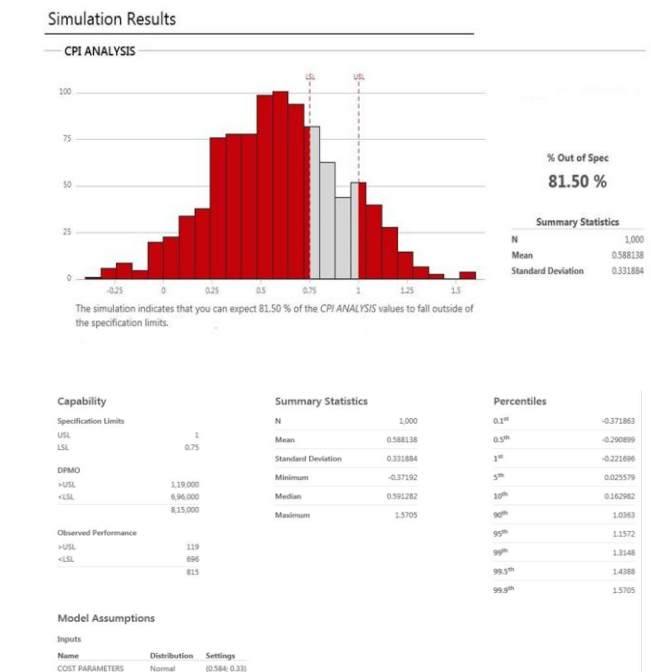
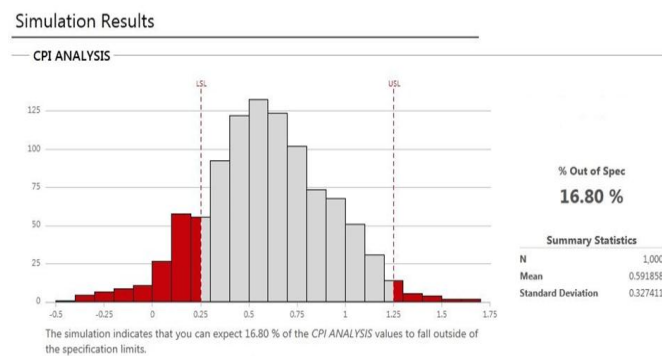


Fig 3: CPI analysis simulation case 2

This is the observed cost performance index from the case study. As most of the construction projects follow the critical path method (CPM), we have to give more consideration for the critical activities in the schedule. That is the commonly adopted procedure. To run the project schedules effectively, we may increase the SPI values of the critical activities and that is good for the project. But when we considering the CPI, it is equally important for both critical and non-critical activities. Cost change will be happened due to the changes in schedules also the factors affecting from every areas of uncertainties.

From the analysis we can see the cost performance index may vary from -0.25 to above 1.5. The variations are measured based on the change in schedule and chances of escalation of cost. So by controlling the schedule progress



and managing better contracts, we can avoid the chances of variation from CPI that we preferred. By this way we can execute the Monte Carlo Simulation in the case study of construction project that we included. After Monte Carlo Simulation we may go for the "Sensitivity Analysis" based on the complexity of the project which will give more visibility in tracking the progress and forecasting.

### 3.2 RESULTS FORM MCS COST ANALYSIS

From both SPI and CPI analysis we can realise that the schedule performance is somewhat good and cost performance shows issues. It means costing may make into clarify. So based on the analysis we can check whether cost overrun occurred in the case study. So it is better to monitor the cost over running based on SPI & CPI; among the suitable key performance index (KPI).

Expected Risk from the SPI Analysis using MCS = **0.90 %**  
Expected Risk from the CPI Analysis using MCS = **16.80%**  
Net Risk can be expected = **17.7 %**

The expected Net risk is given by MCS analysis is 17.7 % and by 66.91 % of the total work schedule completion period the risk is calculated as 7.171 %. It indicates that the Cost should be controlled perfectly for the remaining schedule time of 33.09 %. The controlling over the schedule and SPI is the reason for the present risk level. If we fail to control the SPI of the remaining schedule, definitely the Risk may cover the Net Risk value given by MCS Analysis. Hence from the results it is proved that the assumptions and Risk Analysis of Cost overrun in Highway project is exactly calculated.

### 4. CONCLUSIONS

Cost overruns occur in every construction project and also the magnitude varies considerably from project to project. Just some projects are being completed within the budget. So it's essential to define the particular causes of cost so as to reduce the impact of the increase in cost in any construction project.

The project risk management process doesn't should be complicated or time consuming to be effective. However, these are vital to the complete risk management process. After a team has completed this exercise once, the members are better conditioned on what to concentrate to while managing the project in order that they are more proactive in catching changes or issues early. If these steps within the risk management process are skipped, the team can find themselves in constant reaction mode, simply implementing a contingency plan for every risk at that time risk catches them all of sudden. They may also ignore a seemingly overwhelming list of project risks, which is why narrowing the list all the way down to the foremost important risks is critical for creating sure the list is employed. And also the findings are listed below:

- What if analysis may be used for the research and development type project, especially to finding the probability of occurrence. Most probably it's suit for operation management.
- By using earned value method we will track at this time and trend based status of the time and price factors of the continued projects.
- Project schedules might not be analyzed only by the calculation of physical percentage completions. The hidden uncertainties are often calculated using town simulation techniques.
- Finally, approaches could also be different but the aim are the same; successful completion of the projects.

According to MCS analysis it is concluded that the risk and cost overrun in the project is detected in planning stage, also identify the main factors affecting cost overrun. When all the risk and cost overrun stages are effectively managed then the project is completed in estimated budget. This method is effectively used in future works for reducing cost and risk.

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