An Analysis on Resource Planning, Cost Estimation and Tracking of Project by Earned Value Management

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Abstract- Construction industry is the second largest sector in India. Many construction projects suffer from time and cost overruns due to a multiplicity of factors. Earned value management (EVM) is a project performance evaluation which has been adapted for application in project management. This technique helps in comparison of budgeted cost of work to actual cost. The present study deals with the scheduling and project monitoring process along with it also discusses main parameter's involving in the calculation of earned value analysis in cost and time management of civil construction project. Methodologies and analysis are demonstrated in this paper using an example of real time project. Primavera P6 software is used for project planning and EVM calculations.

Keywords – Earned Value Management, Resource Planning, Cost Estimation, Performance Index, Variances, Primavera P6.

I. INTRODUCTION

Construction industry is important at both global and national level. It provides huge employment to the people and plays very significant role in country economy. Project delay is most common problem in construction industry. Project overruns due to time and cost result in delays during project execution. In developing countries project overrun is serious problem where implementation of project faces many uncertainties. It result in wastage of scare financial resource, delays in providing facilities, development and also makes construction costlier [4]. EVM is the process of measuring performance of project work against a baseline plan. EVM application helps in providing performances standard for the evaluation of progress report project and it also acts as a control device to take care of time and cost schedule by responsibility defined Organization Breakdown Structure (OBS). It provides better performance picture of project and gives better forecast of the final completion cost. Earned value is an enhancement over traditional process of cost accounting [9]. Traditionally budgeted cost is evaluated by computing the difference between planned cost and actual cost incurred in a project. The focus was on planned expenditures and actual cost. Earned value reveals future opportunities and it also examines actual accomplishment. With help of EVM, project managers get sufficient help to have deep intuitive understanding into potential risk areas. So that with help of clearer picture of project performances, managers can create risk mitigation plans based on actual cost, schedule and technical progress of work [1, 9].

II. RESOURCE PLANNING

In planning resource requirement the following points to be considered:
   a) The total resource requirements for a project over its duration.
   b) Minimum delay in completion of the project when insufficient resources are available.
   c) Most efficient utilization of resources to carry out the project in a fixed time.

Resource planning is the process of making sure resources are available as required to execute the project according to schedule. Two types of resource planning problems exist while preparing schedule. In one, the project faces a scarcity of resources and the activities on network must be arranged in such a way that the requirement of resources does not exceed availability. In case such an arrangement is not feasible, the one which gives the minimum additional requirement of resources is chosen. The resources are allocated among competing activities in the order of importance. In other type of resource planning problem the scarcity condition is relaxed and what is needed is to level up the highly fluctuating demand for resources at different times, primarily to facilitate project supervision and enhance efficiency.

III. COST ESTIMATION

Cost estimating is the process of calculating the cost of the identified resources needed to complete the project work. One doing estimating must consider the possible fluctuations, conditions and other causes of variances that could affect the total cost the estimation. There is distinct difference between cost estimating and pricing. A cost estimate is the cost of the resource required to complete the project work. Pricing however includes a profit margin. During the actual execution of the construction, detailed analysis of costs are required to be made. The cost estimates prepared during the design stage may not be sufficient or applicable during the execution stage. During the execution stage, the control estimation system serves two useful purposes.

➢ It develops the production information for materials, labour and equipment that can be used as inputs for future estimates.

➢ It generates information so that one may study to take corrective measures to minimize the cost at any step.

COST ESTIMATE INPUTS

a) Using the Work Breakdown Structure
b) Relying on the resource Requirements
c) Calculating Resource Rates
d) Estimating Activity Duration
e) Historical Information

ESTIMATING PROJECT COSTS

a) Analogous Estimating
b) Parametric Modeling
c) Bottom-up Estimating
d) Computerized Tools

OUTPUTS FROM COST ESTIMATION

a) Cost Estimates
b) Supporting details
c) Cost management plan

IV. CONCEPTS OF EVM

Earned value analysis is a method of performance measurement. Earned value is a program management technique that uses "work in progress" to indicate what will happen to work in future. EVM is system for planning and controlling the project cost performances. EVM establish work packages earned value baseline by integrating project scope, time and cost objectives [6, 8]. This baseline is called as cost control and is used for performance evaluation of project on a given date. Analysis of variance from the baseline provides the cost related information's for problem identification, trend analysis and corrective actions such as re-planning and revising budget. Earned value analysis serves two main purposes, it analyses cost changes which is resulting in time and cost over-run or under-run so that timely corrective actions are taken such as modification of cash flow, updating financial forecast and project profitability expectations. Analysis of variance from baseline using earned value management systems given variety of variances which are analyzed to provide current status of project, to initiate corrective actions and to forecast future trends [6].

V. CASE STUDY

The case study is a Duplex Apartment of "Windmills of Your Mind" at Whitefield, Bangalore. The useful information's has been taken from actual project. Tender document, Bill of Quantities and abstract sheets provides necessary data for project cost and scheduling activities. Total area is 7881 sq.ft. The work should be completed within 160 working days. The project was schedule from 27th January 2014 to 10th July 2014 and four sets of tracking are done at different intervals and final tracking was till 30th June 2014. The main objective of study is to understand the role of EVM for monitoring and control in progress and timely completion of construction project goals are achieved through literature review and methodology involved in Earned Value Management.

VI. METHODOLOGY AND ANALYSIS OF EVM

The construction projects are so vast and complex in nature and therefore for simplification of work, use of software's came into existence. The project was scheduled and monitored using Primavera P6 software. Primavera is the Project Management software use for Planning, Scheduling and Controlling the Construction Project. The steps involved in Duplex Apartment are as follows: Brickwork, Plastering, Flooring, Cabinetry, False Ceiling and Terrace works. The WBS for the project is created and several activities are identified. The durations of the activities are estimated on basis of Historical data, interviews with project manager, applying labour productivity factor formulae and application of analysis of rates. The relationships are examined and applied to the activities. The following procedure involved in scheduling and monitoring projects.

Table 1 PROCEDURE IN PRIMAVERA

1	Create Project
2	Define WBS
3	Creating Calendars
4	Define Activities
5	Appoint Activity Durations
6	Assign Logic Links
7	Perform Scheduling
8	Allocating Resources/Budgeting
9	Creating Baselines
10	Updating schedule
11	Earned Value Analysis
12	Publishing Reports

SCHEDULE ANALYSIS: Earned value is a technique for measuring project performance according to project cost and schedule. The comparison between budgeted and actual performance is performed. There are three earned value parameters as shown below.

Planned Value (PV): It is the cost of the project according to the schedule of the project. It is also called Budgeted Cost of Work Schedule (BCWS).

Earned Value (EV): It is the Budgeted Cost of the Work Performed (BCWP) till date. It is cumulative budgeted cost incurred in activities that have been completed on the due date.

Actual Cost (AC): It is the actual cost that has spent on the project till date. It is also called as actual Cost of Work Performed (ACWP).

The variances are used to check deflection or deviation of project from the path of original schedule. It is also used to analyze the extent and cause for the delays of works or tasks of the project. Following re two variances:

Cost Variances (CV): It is used to check the difference between the proposed planned project and present project on the specific date. It shows the variation of project in form of cost. The formula used for calculating cost variances is

Cost Variance = Earned Value – Actual Cost

Schedule Variance (SV): It is used to examine the deflection of present project in from the planned project. If considerable change appears than the project objectives must be revised. The formula for calculating the schedule variance is

Schedule Variance = Earned Value – Planned Value

Schedule Performance Index (SPI): SPI can be used to estimate the projected time to complete the project. It is calculated as follows,

SPI = Earned Value / Planned Value

SPI = 1 means Project is on Schedule

SPI < 1 means Project is behind Schedule

SPI > 1 means Project is ahead of Schedule

Cost Performance Index (CPI):

CPI can be used estimate the project cost to complete the project based on performance to date. It is calculated as follows,

CPI = Earned Value / Actual Cost

CPI = 1 means Planned and Actual cost are same

CPI < 1 means Project is under Budget

CPI > 1 means Project is over Budget

Estimate at Completion (EAC): The Estimate at Completion is the actual cost to date plus an objective estimate of costs for remaining authorized work. The most common is
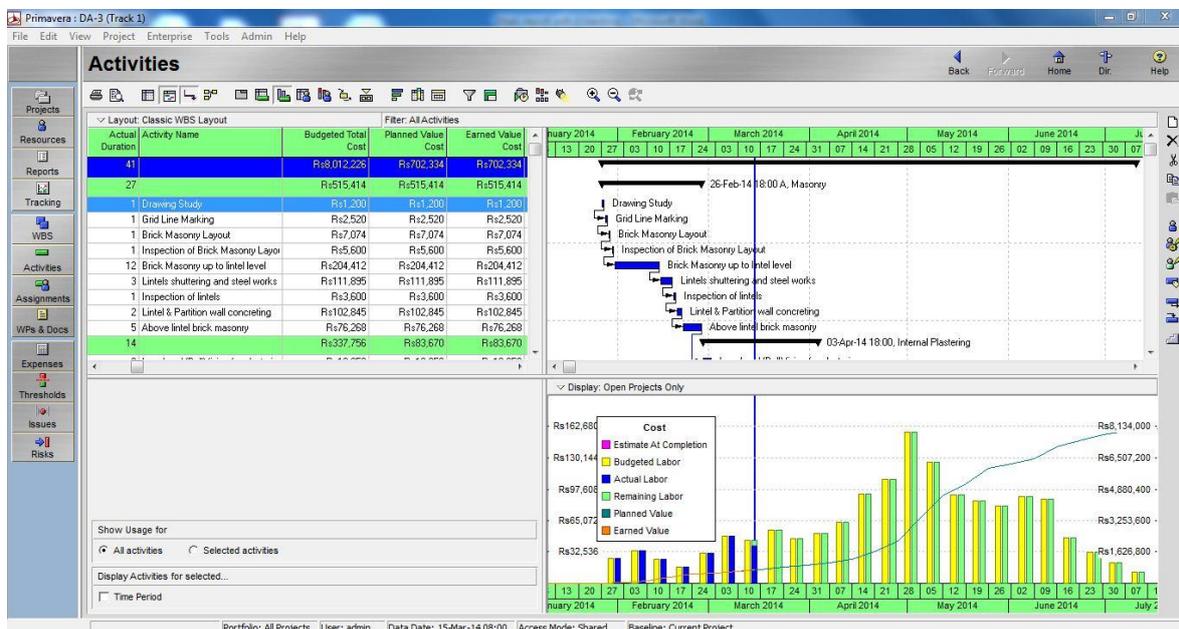
EAC = Actual cost + Estimate to Complete

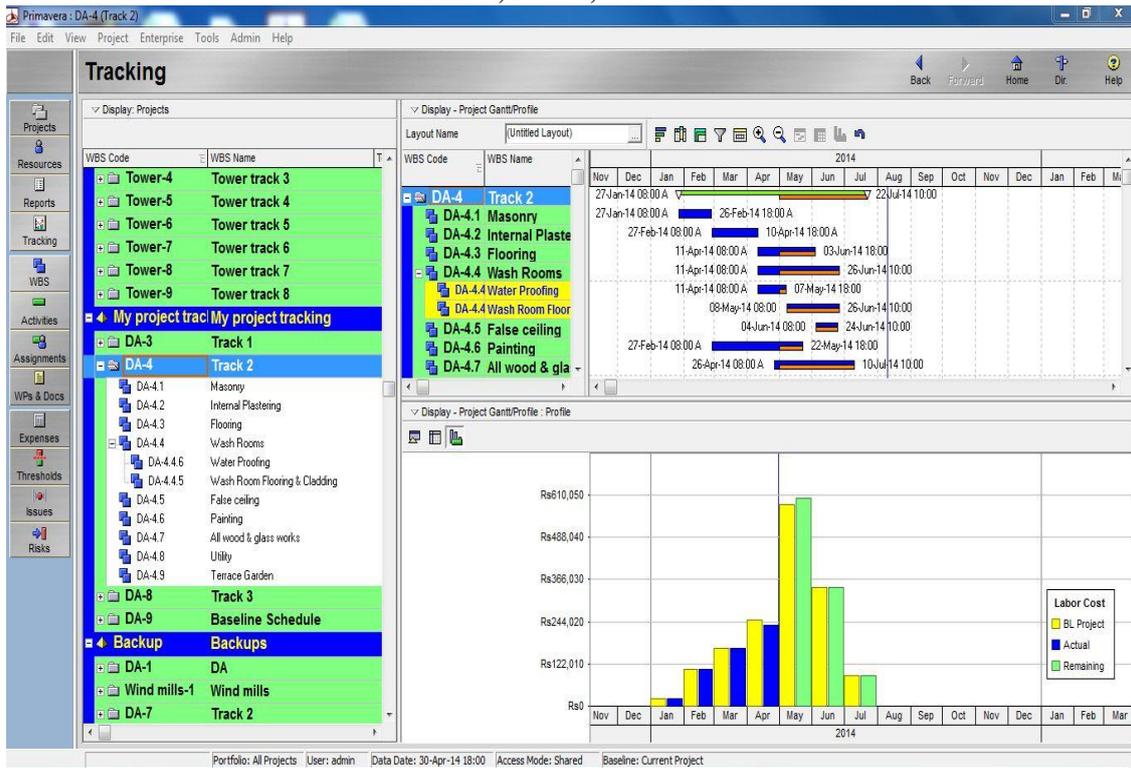**Fig. 1: EVM Parameters, Gantt chart view and S-curve in Primavera**

Fig. 2: Tracking process in Primavera

VII. RESULTS

Table 2 RESULTS OBTAINED FROM PRIMAVERA P6

EVM Paramater	Tracking 1	Tracking 2	Tracking 3	Tracking 4
Budgeted at Completion	Rs. 80,12,225	Rs. 80,12,225	Rs. 80,12,225	Rs. 80,12,225
Planned Value	Rs. 7,02,334	Rs. 27,68,881	Rs. 61,94,005	Rs. 77,29,472
Earned Value	Rs. 7,02,334	Rs. 25,54,523	Rs. 56,13,448	Rs. 68,17,173
Actual Cost	Rs. 7,02,334	Rs. 28,15,802	Rs. 64,51,565	Rs. 80,36,983
Schedule Performance Index	1	0.92	0.90	0.88
Schedule Variance	0	Rs. – 2,14,358	Rs. – 5,80,557	Rs. – 9,12,299
Cost Performance Index	1	0.90	0.87	0.84
Cost Variance	0	Rs. – 2,61,279	Rs. – 8,38,117	Rs. – 12,19,810
Estimate at Completion	Rs. 80,12,225	Rs. 82,73,504	Rs. 88,50,342	Rs. 92,32,035
Planned Schedule % Complete	8.77%	34.5%	77.3%	96.4%
Actual Schedule % Complete	8.77%	32%	70%	85%

Table 3 CUMULATIVE COST AFTER TRACKING 4 FROM PRIMAVERA P6

|	1JAN 2014	1 FEB 2014	1 MAR 2014	1 APR 2014	1 MAY 2014	1 JUN 2014	1 JUL 2014
Planned Value Cost	Rs. 33,428	Rs. 4,97,046	Rs. 4,33,150	Rs.18,05,257	Rs. 34,25,124	Rs. 15,35,467	Rs. 2,82,753
Cumulative Planned Value Cost	Rs. 33,428	Rs. 5,30,474	Rs. 9,63,624	Rs. 27,68,881	Rs. 61,94,005	Rs. 77,29,472	Rs.80,12,225
Earned Value Cost	Rs. 33,428	Rs. 4,97,046	Rs. 3,34,898	Rs. 16,89,151	Rs. 30,58,925	Rs. 12,03,725	-
Cumulative Earn Value Cost	Rs. 33,428	Rs. 5,30,474	Rs. 8,65,372	Rs. 25,54,523	Rs. 56,13, 448	Rs. 68,17,173	-
Actual Cost	Rs. 33,428	Rs. 4,97,046	Rs.3,89,548	Rs. 18,95,780	Rs. 36,35,763	Rs. 15,85,418	-
Cumulative Actual Cost	Rs. 33,428	Rs. 5,30,474	Rs. 9,20,022	Rs. 28,15,802	Rs. 64,51,565	Rs. 80,36,983	-
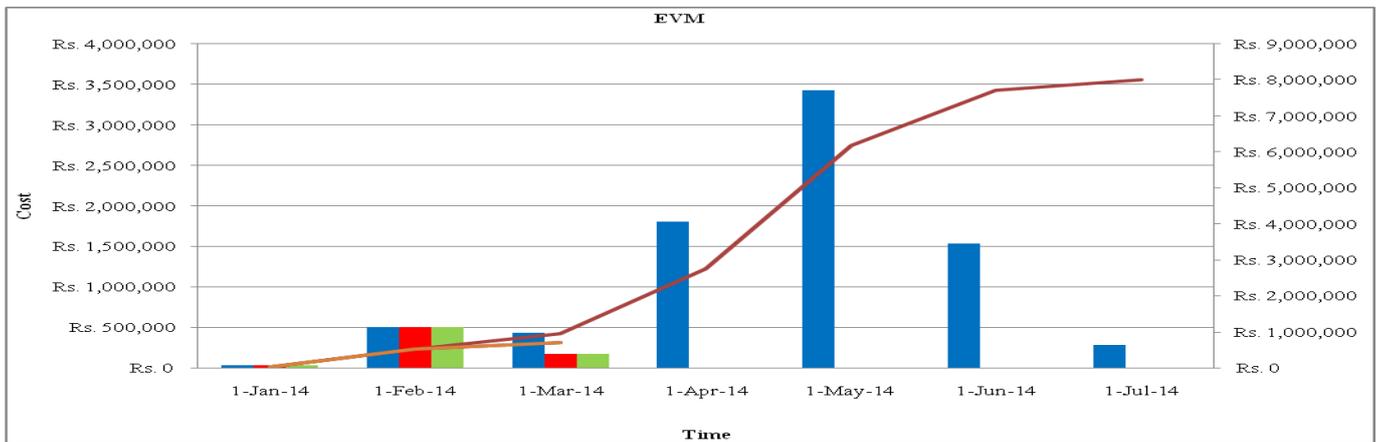
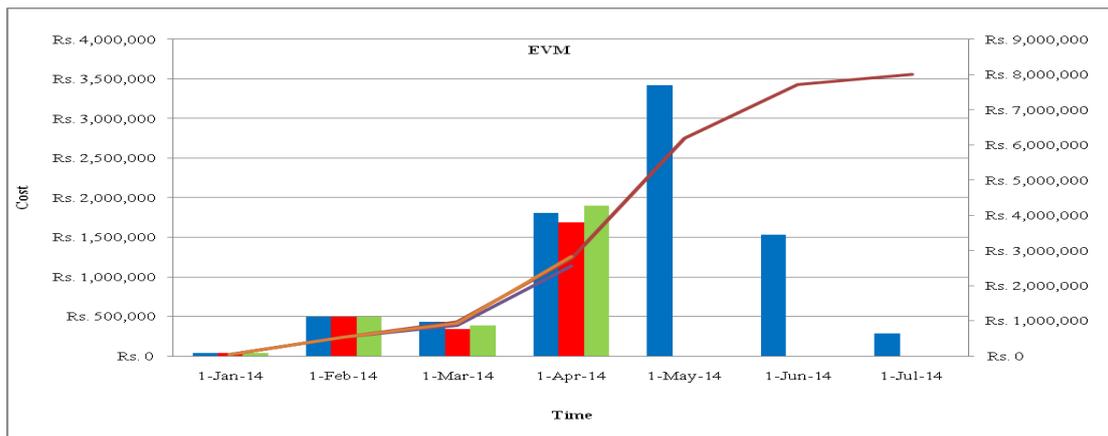**Fig. 3: Earned Value Analysis Graph after First Tracking**

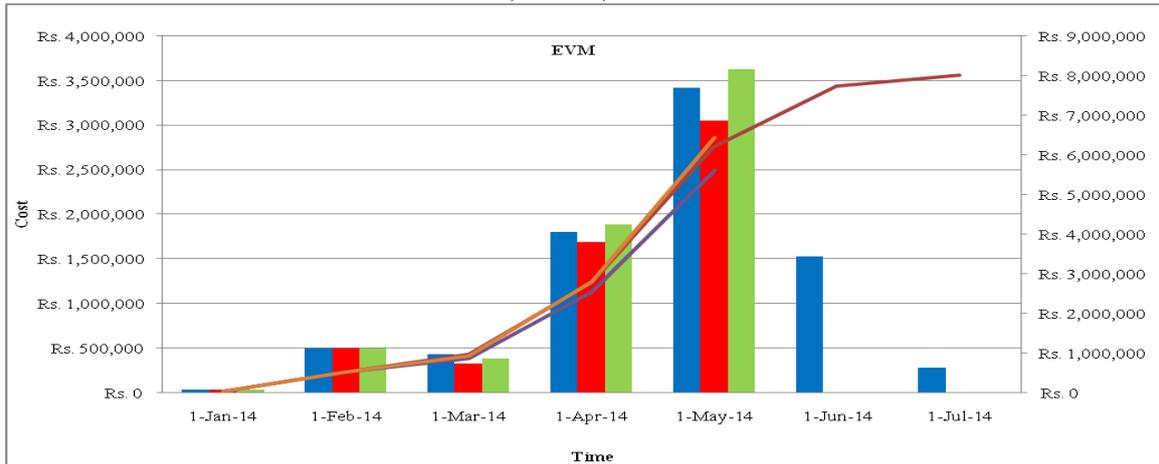**Fig. 4: Earned Value Analysis Graph after Second Tracking**

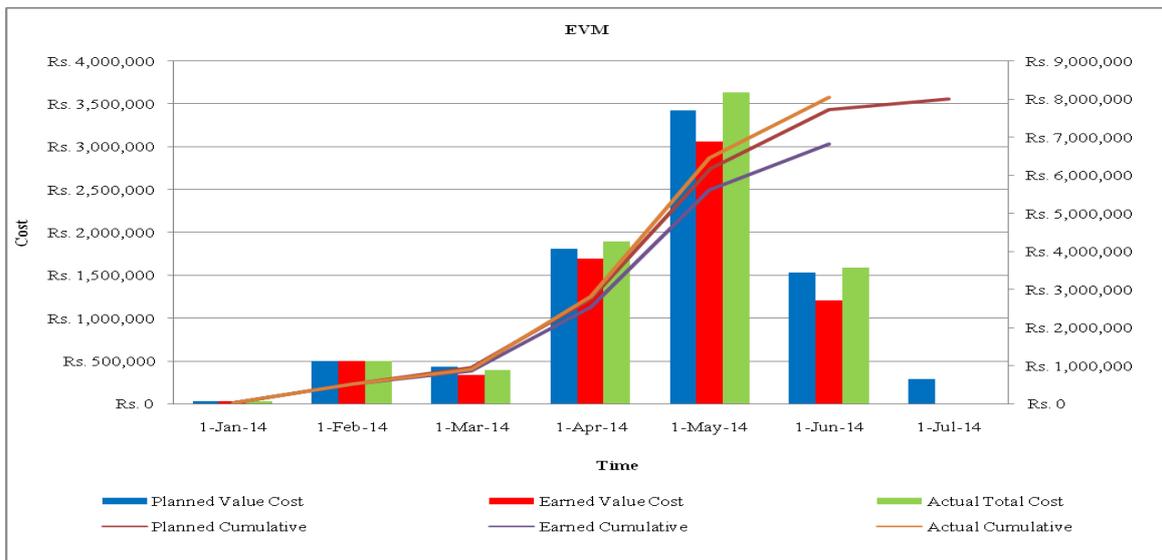**Fig. 5: Earned Value Analysis Graph after Third Tracking**

Fig. 6: Earned Value Analysis Graph after Fourth Tracking

VIII. CONCLUSION

- EVM provides important information for project work package decision making.
- The efficiency of project is demonstrated by SPI is 0.88 which is less than 1 hence project performed less efficiently and running at about 88% of the planned schedule.
- Schedule Variance of the project is Rs. – 9, 12,299 the negative sign determines that project is lagging behind the original schedule.
- CPI indicates the project efficiency of project utilization. For best case scenario, it must be equal to 1 or higher. However for current project is 0.84, this shows that project has low cost efficiency as compared to its spending.

- Cost Variance of the project is Rs. – 12, 19,810 the negative value which depicts an unfavorable scenario. The project is over budget by 16% of overall cost.
- The study shows important, implementation and unique features of EVM that benefits project managers and ultimately results in project success.

The key point here is that Earned Value Analysis enables you to spot a potential problem early in the project and do something to correct the situation. Earned Value Management is a remarkable method of project management because it integrates cost, schedule and scope and can be used to forecast future performances and project completion dates. It allows projects to be managed better on time and in budget.

IX. RECOMMENDATION for FUTURE RESEARCH

The future research in general will include probably new metrics in the EVM methodology to take into account issues like Risk Analysis or Quality and technical performance for an efficient project control. Implementation of EVM creates lot of extra work where it is difficult to integration of company's planning, scheduling, budgeting, work authorization and cost accumulation processes with each other. All these project management constrains likely to exist on most projects. So future research should be aimed to reduce the extra work.

ACKNOWLEDGEMENT

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