Managing cost and schedule to improve performance in construction industry using Earned Value Management: A case study in India

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Abstract - Cost overruns and Schedule delays are the two most important problems effecting the performance of a large scale construction project. To make sure success, an effective project management system for project control must be designed and implemented to provide the concerned managers with correct information about the deviations of cost and time parameters from the target objectives established during the beginning of the project. Earned Value Management (EVM) is a well proved project planning and control technique to improve the performance of a project. Researchers have doubt that the time metrics in EVM did not completely refer to the schedule performance of a project. A noticeable improvement to the EVM is the application of new time metrics called "Earned Schedule "which are based on time units instead of economic units. A 31-month construction project, called "Capital Krishna", was managed by EVM technique in this paper. The paper attempts to explain the application of conventional EVM metrics and compare them with the new metrics and thereby interpret the schedule performance of a project. The satisfactory results related to the application of EVM, are displayed in this paper

Keywords- Cost overruns, EVM, Project control , Risks, Schedule delay.

1. INTRODUCTION

A project management system to measure and convey the progress of a project is termed as Earned Value Management. It allows project to be managed better on time and in budget and also helps the manager to measure the performance of the project and take timely actions. It compares actual accomplishment of work that is scheduled and the related cost against an integrated schedule and budget plan. The earned value technique introduces a quantitative measure for the Budgeted Cost of Work Performed (BCWP) by crediting budgeted money to scheduled work as it is performed. It is a management technique that uses "work in progress" to indicate what will happen to the work in future. Earned Value examines actual accomplishment .This gives planning engineers a greater insight into potential risk areas. With clearer picture, planners can create risk mitigation plans based on actual cost, schedule and technical progress of the work. It allows projects to be managed better – on time, on budget.

2. LITERATURE REVIEW

The Measurable News, published by the Project Management Institute College of Performance Management (PMI-CPM) has been one of the key sources of information on EVM. They are focused on project performance management, and therefore The Measurable News, presents many in depth articles by academics and practitioners who are active in the study or use of EVM. Lambert (1993) describes the concept of cost/schedule control system criteria (C/SCSC) which is the forerunner of EVM. In one table, Lambert provides some sample comparisons of EV, PV and AC values. In doing so, he actually identifies the nine unique conditions that can exist in EVM analysis. (Lambert 1993a, p. 190).

Lipke, expanding from earlier work described by fleming [1] has developed and described the concept of "EARNED SCHEDULE". The concept creates time or duration based indicators which are used instead of units of cost or value for measuring schedule performance. Earned schedule (ES) extension to Earned Value Management (EVM) theory is discussed in the sources by Lipke [5] and Henderson [6]

Literature review reveals that in construction projects, the EVM and ES plays a very important role in project control. Project control combines monitoring performance and taking corrective action. Project performance researchers are undisputed that the conventional Earned Value Management is a very good tool to calculate project cost performance. On the other hand, they have much more divergent opinions about the EVM capacity to provide reliable schedule performance indicators. Earned Schedule analysis is a breakthrough analytical technique that derives schedule performance measures in units of time, rather than cost.

3. Methodology

Poor project performance is very much evident for mega-projects. A number of studies have compared the predicted costs to the final costs of megaprojects. Even though there are some mega-projects that have been completed under- or on-budget, a far bigger number have been completed with significant overruns.
A second factor that is very much related to the cost is the time to complete the project. Initial predictions tend to be too optimistic, and a large percentage of megaprojects finish far behind the scheduled timeframe. In contrast to smaller projects that may take only little months to a year to complete, megaprojects take several years to finish. Delays in projects of this extent can lead to few extra years and can lead to additional cost.
The methodology of the thesis consists of performing site visit, preparing the work schedule and thereby collecting the earned value datas. The trend indicators were calculated using the earned value analysis and earned schedule analysis. the results were obtained and were interpreted.
The Planned Value is an indication of the budgeted work that is scheduled to be performed, and it is the established baseline against which the actual progress of the project is measured [7].
The EV reflects the amount of work that has actually been accomplished to date, expressed as the planned value for that work [7].

Actual Cost of Work Performed (ACWP) is the total expenditure for tasks or sub-tasks at any point in time.
The three basic metrics of EVM can be used to analyze project's present situation at any time during the project.
Cost Variance (known as CV) is used to analyze the project in terms of cost performance. The CV is the result of the following sum

$$CV = EV - AC \quad (1)$$

The Cost Performance Index (CPI) is used as a key measure for analyzing the project cost efficiency. It can be found out from the equation

$$CPI = EV/AC \quad (2)$$

Schedule Variance (known as SV) is used to analyze the project in terms of time performance. It can be found out from the equation

$$SV = EV-PV \quad (3)$$

The Schedule Performance Index (SPI) indicates how efficiently the project team is using its time. It can be found out from the equation

$$SPI = EV/PV \quad (4)$$

3.1 Beyond EVM -Forecasting using Earned Schedule

The SV is measured in economic units making it very difficult for understanding and it leads to misinterpretations .SV = 0 (or SPI = 1) could convey that an event is finished, but it could also convey that the task is still running as per planned. So confusion arises [11]
To solve the problems related to schedule performance some other factors and related metrics can be introduced. The main one is the concept of earned schedule (ES). Lipke conceived the ES concept during 2002 and published the ES seminal paper "Schedule is Different" (Lipke 2003) in the March 2003 edition of the PMI College of Performance Management Journal, The Measurable News. Instead of using cost for measuring schedule performance, we would use time. Earned Schedule is determined by comparing the cumulative BCWP earned to the performance baseline, BCWS. The time associated with BCWP, i.e. Earned Schedule, is found from the BCWS S-curve.
Expressed algebraically, ES cum is the number of completed PV time increments EV exceeds PV plus the fraction of the incomplete PV increment in the unit of time (i.e. weekly or monthly) being utilized. Therefore,

$$ES\ cum = C+I \quad (5)$$

C is the number of time increments where EV exceeds PV;

$$I = (EV - PV_{(C)}) / (PV_{C+1} - PV_C) \quad (6)$$

Using ES, indicators can be formed which behave appropriately and analogously to the cost indicators:

Schedule Variance

$$SV\ (t) = ES - AT \quad (7)$$

Schedule Performance Index:

$$SPI\ (t) = ES/AT \quad (8)$$

3.2 The Case Study: "Capital-Krishna" Flat Project.

An organization, was selected which was capable of adopting the EVM.A project team was assigned to calculate the project cost and time trends. The common EVM metrics that include planned value, earned value and actual cost are required for applying EVM calculations in a project.
The selected case is a project titled "Capital Krishna" flat project which is the construction of flat located in India. This project has been checked during the planning and the execution phases. The project comprised of 31 months. The results of monthly PV, EV and AC reports, up to the

25th month of the project commencement were collected by the assigned project team. These are presented in Table 1.Table 2 and Table 3 shows the cost and time EVM parameters.

Table 1 Cumulative PV, EV & AC

Month	Cum. PV(in lakhs)	Cum. EV(in lakhs)	Cum. AC(in lakhs)
Mar	2.5	2.6	10.1
April	6.8	7.9	22.12
May	15.3	16.5	38.81
June	25	29	53.21
July	41	48.8	71.23
Aug	58.9	66.26	98.62
Sept	84.8	98.95	123.43
Oct	109.9	127	152.35
Nov	144.9	153.8	182.19
Dec	181.2	188.8	225.1
Jan	223.8	225	258.4
Feb	262.4	251.11	289.76
Mar	305.5	293.34	329.2
April	345.9	308.8	356.67
May	393.3	352.2	394.12
June	432.4	388.6	428.91
July	479.6	427.3	464.25
Aug	519.2	479.1	500.37
Sept	566	498.5	539.29
Oct	608	545.2	580.39
Nov	651.2	569.32	617.98
Dec	692.1	621.17	649.91
Jan	729.8	661	686.11
Feb	763.4	692.13	723.87
Mar	796	724.85	763.74

Table 2 EVM Parameters (cost)

Months	CV	CPI	Result
Mar	-7.5	0.257426	Over budget
April	-14.22	0.357143	Over budget
May	-22.31	0.425148	Over budget
June	-24.21	0.54501	Over budget
July	-22.43	0.685105	Over budget
Aug	-32.36	0.671872	Over budget
Sept	-24.48	0.801669	Over budget
Oct	-25.35	0.833607	Over budget
Nov	-28.39	0.844174	Over budget
Dec	-36.3	0.838738	Over budget
Jan	-33.4	0.870743	Over budget
Feb	-38.65	0.866614	Over budget
Mar	-35.86	0.891069	Over budget
April	-47.87	0.865786	Over budget
May	-41.92	0.893636	Over budget
June	-40.31	0.906018	Over budget
July	-36.95	0.920409	Over budget
Aug	-21.27	0.957491	Over budget
Sept	-40.79	0.924364	Over budget
Oct	-35.19	0.939368	Over budget
Nov	-48.66	0.92126	Over budget
Dec	-28.74	0.955778	Over budget
Jan	-25.11	0.963402	Over budget
Feb	-31.74	0.956152	Over budget
Mar	-38.89	0.94908	Over budget

Table.3 EVM Parameters (time)

SPI	SV(t)	SPI(t)	RESULT
1.04	0.02	1.02	On time
1.161765	0.13	1.06	On time
1.078431	0.12	1.04	On time
1.16	0.25	1.06	On time
1.190244	0.44	1.09	On time
1.124958	0.28	1.05	On time
1.166863	0.56	1.08	On time
1.155596	0.49	1.06	On time

1.061422	0.25	1.03	On time
1.041943	0.18	1.02	On time
1.005362	0.03	1.00	On time
0.956974	0.29	0.98	Behind schedule
0.960196	0.28	0.98	Behind schedule
0.892744	0.92	0.93	Behind schedule
0.8955	0.87	0.94	Behind schedule
0.898705	1.10	0.93	Behind schedule
0.890951	1.13	0.93	Behind schedule
0.922766	1.01	0.94	Behind schedule
0.880742	1.52	0.92	Behind schedule
0.896711	1.44	0.93	Behind schedule
0.874263	1.92	0.91	Behind schedule
0.897515	1.70	0.92	Behind schedule
0.905728	1.76	0.92	Behind schedule
0.906641	2.00	0.92	Behind schedule
0.910616	2.13	0.91	Behind schedule

- The project has an unfavourable Schedule Variance of -71.15 that means the project is behind schedule.
- A SPI of 0.91 would tell us that the project is only progressing at 91% of the rate originally planned. SPI indicates the rate at which the project is progressing.
- The originally estimated completion time for the project was 31 months, so the project manager now knows that if work continues at the current rate the project will take 3.04 months longer than originally planned as time estimate at completion is 34.04 months
- The project has an unfavourable Cost Variance of -38.89 that means the project is over budget.
- A CPI of 0.94 would tell us that the project is currently running over budget.
- Estimate at completion shows the expected total cost of a project at completion, based on performance as of the data date. Rs.891.5lakhs divided by 0.94 is Rs. 939.33lakhs; therefore EAC is Rs. 939.33lakhs.
- Variance at completion shows the variance of total cost of the work and expected cost. Here it is -47.83 that means at this status date the project is over budget by Rs. 47.83lakhs.
- Estimate to Complete shows the expected cost required to finish all the remaining work. Here it is Rs.175.59lakhs, this much is needed to complete the remaining work.

4. CONCLUSION

The results of this thesis show the importance of project performance measuring techniques like EVM as well as ES in improving the performance of a construction project. This paper proves the application of the Earned Value Management (EVM) and Earned Schedule (ES) in managing the cost and time performance of a Flat Construction Project in India called “Capital Krishna”, particularly in Kerala state. Through this analysis, we could compare the efficiency in forecasting various parameters related to the status of the project. The key EVM metrics were calculated using the cost related findings that have been recorded. Also a new set of EVM metrics has been practiced in this project. The previous method has been compared with the new one. While considering the schedule performance, most of the recent research suggests that the results calculated with Earned Schedule are better than those calculated with conventional EVM. Nevertheless, many of them claim that Earned Schedule works very well to predict the schedule performance of a project. It express schedule performance in time units and is reasonably reliable. In our opinion, the EVM rules and standards related to schedule performance should be changed according to the Earned Schedule approach as it proves to be more accurate measuring schedule based on time units instead of money units. But for forecasting the cost performance parameters EVM is a very dependable solution. It works very well for measuring the cost performance of the project. The results show that the specific project is over budget and behind schedule in general. The results can help the project managers to know the present situation of the project so that they can manage the project expenditure in the best way and thereby improve the project performance.

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