Application of earned value method and earned schedule method for a residential apartment

Vaibhava S1, B Prakash Rao2*, Dheeraj Vishwanatha Shetty3 and Chandra Prakash4

1MFAR Constructions Private Limited, Bengaluru, India
2,3,4Department of Civil Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal - 576104, Karnataka, India

* E-mail: bp.rao@manipal.edu

Abstract: Earned Schedule Management (ESM) gives an estimate of schedule and milestone achievement dates. Earned Value Management (EVM) assists to follow the project performance by giving the schedule variance, cost variance and their performance index. EVM & ESM helps the project manager to foresee cost and schedule for the real project. The objective of this study is to apply EVM & ESM to the real time residential apartment project which is upcoming in Bengaluru, Karnataka, India and then to compare the results of two deterministic forecasting methods EVM and ESM. The EVM and ESM parameters are generated by using the data procured from the planning department. It shows much fluctuation in the project performance but the last months (M10) results reveal that the project is behind schedule, unfavorable budget and needs more amelioration. The project has an unfavorable Cost Variance of -0.91 (budget in crores of INR, 1 crore =10 millions) and schedule variance of -6.71 months. It is also observed from the results and actual project situations that Earned Value and Earned Schedule methods in conjunction gives more accurate interpretation than using each of them detachedly.

1. INTRODUCTION

The construction industry has important nexus with other sectors, so that its influence on Gross Domestic Product (GDP) and economic progress goes well beyond the direct contribution of construction activities. According to the ministry of statistics and programme implementation (2018-2019) construction sector accounts for 7.54% of total India's Gross Value Added (GVA) of 169.61 lakh crore (1 crore =10 millions) Indian rupees. Earned Value Management (EVM) and Earned Schedule Management (ESM) help project managers to measure project performance. These are the organized project management procedure used to find variances in projects based on the comparison of work performed and work planned. Earned Value method is a well-known project management tool that utilizes intimation on cost, schedule and work performance to establish the current status of the project. Earned Schedule (ES) provides, how much duration has been earned from the planned duration of the project. ES is a valuable extension to EVM, requires no additional data collection, and provides valuable insights into the project schedule and forecast of its outcome. ES is a reliable technique to measure the schedule performance. In brief, Earned Schedule yields time-based indicators, unlike the cost-based indicators for schedule performance offered by EVM. Both EVM and ES techniques can provide future awareness for making finer decisions about project performance.
2. LITERATURE REVIEW

Amruta and Birajdar [1] explained that EVM helps in decision making for the future works. It is useful in identifying risk factors and in predicting future work problems. Study by Ankur Verma [2] shows importance, implementation & unique features of EVM that benefit for the project success. Kym Henderson [3] applied Earned Schedule measures to 6 small and subprojects that Lipke’s ES concept is valid. He found that, in this study Earned Schedule metrics behave more consistently than their counterparts, EVM’s cost-based schedule performance method because they have been correlated correctly to project’s actual schedule performance for both late and early finish. Stephan and Mario [4] conducted a study to compare earned value performance indicators with the earned schedule indicators. This study was carried out to foresee the duration forecasting formula. Finally, earned schedule was found more accurate for schedule forecasting than the earned value technique. Walt Lipke [5] showed the flaws in the schedule parameters used in EVA, when the project is behind schedule and has exceeded the estimated completion date. In such cases Earned Schedule is introduced so as to achieve a more accurate result. Walt Lipke [6] discussed that Earned Schedule is shown to be useful to project managers to control and analyze project schedule performance.

3. OBJECTIVES

i) To compare the results derived from Earned Value and Earned Schedule analysis.

ii) To forecast the project progress in term of budget and schedule and to control the problems in potential risk areas.

4. METHODOLOGY

- Literature review on earned value and earned schedule management are made
- Objectives of the study are identified.
- Schedule for each activity is prepared using Primavera.
- Planned Values are extracted for each month from the planned monthly profit and loss sheet which is made using the initial rate analysis.
- The project is updated according to progress of the work at the end of every month. Update actual monthly expenses i.e., Actual Costs incurred in the project using the Enterprise Resource Planning (ERP).
- Trend Indicators of the project such SV, SPI, CV, CPI, TCPI, TSPI and CR ratio are calculated from the equations, using Planned Value, Actual Cost and Earned Value for each month and milestone.
- Using Earned Value Analysis the cost and time to complete the project and the efficiency required to achieve the target are forecasted
- Earned Schedule Analysis on the Project is performed
- Results obtained from EVA and ESA are compared
- Conclusion is drawn based on the analysis.

5. CASE STUDY

The present study is made on a residential apartment complex in Bengaluru, India. The project start date is 16th April 2018 and supposed to be completed by 15th January 2020. The study is made for 10 months between June 2018 and March 2019. These months are represented from M1 through M10.

Table 1. displays Planned Value (PV), Actual Cost (AC) and Earned Value (EV) is extracted from the schedule for every month. The project is updated according to progress of the work at the end of every month. The total budget of the project is Rs. 136 crores. The Actual Cost incurred and Earned Value for the project is noted after every month. At few stages of execution, it is noted from the table that...
Earned Value is less than the Planned Value, indicating delay in execution of the work. Further Earned Value is slightly less than the Actual Value, indicating a slight budget overrun in execution of the work.

**Table 1. Planned Value (PV), Actual Cost (AC) & Earned Value (EV)**

| Month | PV  | Income | AC   | Schedule Complete | Spent EV |
|-------|-----|--------|------|-------------------|----------|
| M1    | ₹ 0.74 | ₹ 0.51 | ₹ 0.76 | 0.56% | 0.55% | ₹ 0.74 |
| M2    | ₹ 2.10 | ₹ 1.44 | ₹ 2.65 | 1.12% | 1.54% | ₹ 2.10 |
| M3    | ₹ 2.10 | ₹ 1.44 | ₹ 2.60 | 2.23% | 1.54% | ₹ 2.10 |
| M4    | ₹ 3.04 | ₹ 2.08 | ₹ 2.74 | 2.23% | 2.23% | ₹ 3.04 |
| M5    | ₹ 1.56 | ₹ 1.07 | ₹ 0.81 | 1.31% | 1.15% | ₹ 1.56 |
| M6    | ₹ 1.30 | ₹ 0.89 | ₹ 1.08 | 1.18% | 0.95% | ₹ 1.30 |
| M7    | ₹ 1.58 | ₹ 1.08 | ₹ 1.86 | 1.56% | 1.16% | ₹ 1.58 |
| M8    | ₹ 1.59 | ₹ 1.09 | ₹ 1.23 | 1.18% | 1.17% | ₹ 1.59 |
| M9    | ₹ 1.75 | ₹ 1.20 | ₹ 2.00 | 2.02% | 1.29% | ₹ 1.75 |
| M10   | ₹ 2.04 | ₹ 1.40 | ₹ 2.95 | 2.46% | 1.50% | ₹ 2.04 |

All monetary data are in crores of INR (₹) (1 crore =10 Millions)

5.1. Cost analysis using EVM

Table 2 shows that the Cost Variance (CV) is negative in the months M1, M2, M3, M7, M9 & M10 which implies the project is over budget. The project has an unfavourable Cost Variance of -0.91 in the month M10. Cost Performance Index (CPI) should be equal to one, to say that the project is on budget. In this case value of CPI less than one implies the project to be cost overrun. A CPI of 0.69 in the month M10 confirms us that the project is currently cost overrun with progress of the project. To Complete Performance Index (TCPI) is 1.01 in M10 which shows that for the project to achieve the Budget at Completion (BAC), performance need to be slightly improved. Critical ratio (CR) is shown in the last column

| Month | CV  | CV%  | CPI  | TCPI | CR  |
|-------|-----|------|------|------|-----|
| M1    | -₹0.02 | -2.44% | 0.97 | 1.00 | 0.95 |
| M2    | -₹0.54 | -25.86% | 0.79 | 1.00 | 1.09 |
| M3    | -₹0.50 | -23.63% | 0.80 | 1.00 | 0.55 |
| M4    | ₹0.30  | 9.80%  | 1.10 | 1.00 | 1.10 |
| M5    | ₹0.75  | 48.17% | 1.92 | 0.99 | 1.69 |
| M6    | ₹0.22  | 16.91% | 1.20 | 1.00 | 0.97 |
| M7    | -₹0.28 | -17.92% | 0.84 | 1.00 | 0.63 |
| M8    | ₹0.36  | 22.74% | 1.29 | 1.00 | 1.27 |
| M9    | -₹0.25 | -9.00% | 0.87 | 1.00 | 0.55 |
| M10   | -₹0.91 | -27.02% | 0.69 | 1.01 | 0.42 |

CV is in crores of INR (₹) (1 crore =10 Millions)

5.2. Schedule analysis using EVM

Table 3 shows that the Schedule Variance (SV) is negative throughout the execution of the project (except for months M2 and M4) from which we can infer that the project is behind schedule. In the last few months, SV worsened with the progress of the project, which might prove to be unrecoverable at the end. Schedule Performance Index (SPI) of 0.61 in the last month M10 shows that project progressed only 61% of planned schedule. Estimate at Complete Time (EACt) is shown in the last column
Table 3. SV, SV%, SPI and EAC(t)

| Month | SV  | SV%  | SPI  | EAC(t) |
|-------|-----|------|------|--------|
| M1    | ₹ 0.02 | -1.99% | 0.98 | 24.49  |
| M2    | ₹ 0.57  | 37.46%  | 1.37 | 17.46  |
| M3    | ₹ 0.94  | -30.82% | 0.69 | 34.69  |
| M4    | ₹ 0.00  | -0.07%  | 0.99 | 24.02  |
| M5    | ₹ 0.22  | -12.21% | 0.87 | 27.34  |
| M6    | ₹ 0.31  | -19.26% | 0.80 | 29.73  |
| M7    | ₹ 0.54  | -25.60% | 0.74 | 32.26  |
| M8    | ₹ 0.02  | -1.12%  | 0.98 | 24.27  |
| M9    | ₹ 1.00  | -71.24% | 0.63 | 37.66  |
| M10   | ₹ 1.31  | -38.96% | 0.61 | 39.32  |

SV is in crores of INR (₹) (1 crore = 10 Millions)

5.3. Schedule analysis using ESM
From Table 4, it can be observed that the Schedule Variance Time (SV(t)) is negative. The Schedule Variance time has a value of -6.71 for the month M10 which means the project is running behind the schedule by 6.71 months. The negative sign indicates that the condition is unfavorable. Here, the value of Schedule Performance Index Time SPI(t) equals 0.32 shows that the performance is unsatisfactory. The total duration of the project is 21 months but Independent Estimate of Time at Completion (IEAC) has a value of 72.95 months; it means project takes extra 51.95 months to complete all activities.

Table 4. ES, SV(t), SPI(t) and IEAC

| Month | ES   | SV(t) | SPI(t) | IEAC(months) |
|-------|------|-------|--------|---------------|
| M1    | 1.76 | 0.76  | 1.76   | 13.61         |
| M2    | 3.04 | 1.04  | 1.52   | 15.75         |
| M3    | 3.00 | 0.00  | 1.00   | 24            |
| M4    | 3.77 | -0.22 | 0.94   | 25.44         |
| M5    | 2.88 | -2.11 | 0.57   | 41.53         |
| M6    | 1.80 | -4.19 | 0.30   | 79.67         |
| M7    | 2.95 | -4.04 | 0.42   | 56.93         |
| M8    | 2.33 | -5.66 | 0.29   | 82.27         |
| M9    | 2.14 | -6.85 | 0.23   | 100.62        |
| M10   | 3.29 | -6.71 | 0.32   | 72.95         |

All times are in months

5.4. Comparison of the results obtained from EVM & ESM
It can be seen from Figure 1 that Schedule Performance Index (SPI) derived from EVM is .610 for the month M10, whereas the Schedule Performance Index Time (SPI(t)) derived from ESM is 0.329. This implies that the schedule performance shown by ES indicates that the project is doing worse than what was indicated by the EV method. In this case, the divergence between SPI and SPI(t) begin from the starting of project development.
Figure 1. SPI vs SPI (t)

It can be observed from Figure 2 that Schedule Variance (SV) derived from EVM indicates the project is in an ideal phase in last month M10, but Schedule Variance Time (SV(t)) from ESM analysis shows that the project is behind the schedule. Compared to the site situation, EVM shows much varied schedule result which it is not realistic.

Figure 2. SV vs SV(t)

6. CONCLUSION

The Schedule Variance time has a value of -6.71; which shows that the project is presently running behind by 6.71 months. The project has an unfavorable Cost Variance of -0.91 & Estimate at Completion is Rs.196.53crores that means the project is over budget. As per this study, EVM is better method to forecast budget variance, and ES is better method to forecast schedule variance. Thus, using any one method separately does not give realistic conclusion. It is better to employ both the methods simultaneously to arrive at a better result.

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