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Application of Earned Value and Earned Schedule to Construction Project

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Abstract: ***Earned Value Management (EVM) is a powerful methodology used in the monitoring and controlling of the project. By applying this methodology on the project, it gives executives, project managers and other stakeholder's ability to visualize project status throughout lifecycle of the project and helps to manage project more effectively. Earned Schedule (ES) is an extension to the theory and practice of Earned Value Management. The earned schedule allows earned value management metrics to be transformed to time or duration metrics to enhance the evaluation of the project schedule performance and to forecast the duration needed to complete the project. The earned schedule enhances the project manager's understanding of project schedule forecasts and becomes useful for making better decisions about project schedule. This paper discusses the project manager's considerations and applicability of earned value management and earned schedule. It gives alerts to the project manager that where is he in the project, whether his project is behind schedule, ahead schedule or on schedule.***

Keywords: Earned Value Management (EVM), Earned Schedule (ES), Project Monitoring, forecasting project outcomes

1. Introduction

Due to versatile nature of construction, project manager needs strict monitoring and control over the project. Monitoring is the most important component in project management. It deals with measuring performance of project at certain time interval and reports that performance to organization for process control. After getting such monitored information, the concerned authority decides further action that is called controlling. Thus, monitoring and controlling is a persistent process throughout entire duration of project.

Earned value management was originally developed for cost management and has not widely been used for forecasting project duration. However, recent research trends show an increase of interest to use performance indicators for predicting total project duration. It is extremely natural to think project schedule performance in terms of time rather than cost. Earned value measures performance of project in terms of cost. In addition, EVM method truthfully follows for project that finishes on time. Unfortunately, its schedule indicator loses its predicting ability for late finish projects especially at final one third of project. EVM shows schedule variance equal to zero and schedule performance index equal to unity even when project finishes unacceptably late. We know the project completed late, yet the indicator values say the project has perfect schedule performance. Thus, a new concept is introduced called earned schedule.

Earned schedule (ES) is an advanced analytical method that resolves the EVM problem. It is derived from and is an extension to EVM. No additional data is needed for acquiring the ES measures; only the data from EVM is needed. In contrast to the cost-based indicators from EVM, the ES schedule performance indicators are time-based, making them easier to understand. The ES indicators provide a status and predictive ability for schedule, similar to the facility for cost using EVM. Since the earned schedule metrics use time based measures, they expand traditional EVM and incorporate schedule analysis. Earned schedule is the link between EVM and schedule analysis. It has been shown that ES can be used for complete schedule analysis and that it has the potential to improve both cost and schedule prediction.

2. Literature Review

Performance efficiency is measured by the Earned Value Management (EVM) cost performance index, CPI, and the Earned Schedule (ES) schedule performance index, SPI(t). Project managers using EVM and ES in their management practice, thus, have a set of indicators, which provide information concerning the health of their project. If the project is performing at the planned efficiencies (CPI and SPI (t) equal to 1.0), the project is forecast to complete at the planned cost, and deliver its product on the expected delivery date. And, none of the planned reserves for cost or schedule will be consumed.

One method of forecasting whether a project will complete within its funding and negotiated delivery date is to compare the inverse indexes to ratios, which include the cost and schedule reserves. When the value of CPI is less than or equal to the cost ratio, the project manager has an expectation that the project will complete within the funding allocated. Correspondingly, if SPI (t) is less than the schedule ratio, the project is expected to finish by the negotiated completion date.

Of course, when the inverse indexes are greater than their respective ratios, the project manager knows his project is in trouble. The forecast indicates the plan will be exceeded, the reserves will be consumed, and more resources (time and funding) are needed. Understanding the project is failing, the project manager is inclined to take corrective action. And, certainly the pressures from upper management and the customer compel the project manager to show that corrective action is already in progress.

It may not be, but the project manager doesn't have anything in his tool kit to say he should do otherwise. Therefore, being proactive is his sole choice. Furthermore, the project manager knows that doing something, right or wrong, will buy time. Wishfully, within that time, a miracle happens and the project gets back on course. If good luck comes his way, the project is "righted," and our hero receives a bonus and maybe even a promotion.

More than likely, the outcome of a reactionary corrective action will not be effective. As mentioned previously, any change to the execution of the plan causes inefficiency. If the action taken is not the correct one, then management has inadvertently worsened the project performance and has not helped the situation. Subsequently, the manager, being proactive, takes another "shot in the dark," likely worsening the situation, once again. This process repeats until it becomes obvious to all concerned that the only way to deliver the product is to negotiate additional time and funding. The outcome of this negative spiral is the company and the project manager gain poor reputations. Additionally, if the product is extremely important and its sunk cost is significant with respect to the amount needed for completion, the agitated customer will likely agree to the added cost and delivery date extension. Under these circumstances, the company cannot expect repeat business or future recommendations from this customer.

Another common earned value approach is to manage using the cost variance (CV) percentage; i.e., CV divided by the EV. With this method the project manager takes corrective action upon breaching an arbitrary limit; e.g., plus or minus 10 percent. Generally, the results from the CV management method are as poor as described for CPI.

Certainly, there are successful projects, which have been managed using earned value indicators; we are not implying earned value management has no merit. Using earned value coupled with earned schedule as a project management method greatly increases the opportunity for success, but improvement is needed. Project performance data is readily available, but rarely is it used advantageously. This is the state of today's management practice.

Until the mid-nineteenth century, the general method of design did not change a lot. Engineers used simple tools (such as pen, paper and ruler) to describe their buildings. However, with advances in mathematics and building materials, the process of design changed and improved rapidly.

3. Elements of Earned Value Management

EVM integrates three critical elements of project management: scope management, cost management, and time management. It requires the periodic monitoring of actual expenditures and the amount of work done (expressed in cost units). To determine cost performance, EVM compares how much we have spent to what we planned to have spent to do the work we have done. To determine time performance, it compares the amount of work done to the amount of work scheduled to be done. To make these comparisons, EVM calculates cost and schedule variances, along with performance indices for project performance management. Based on these results, it forecasts the date and cost of the project at completion and highlights the possible need for corrective action. EVM uses the following project parameters to evaluate project performance:

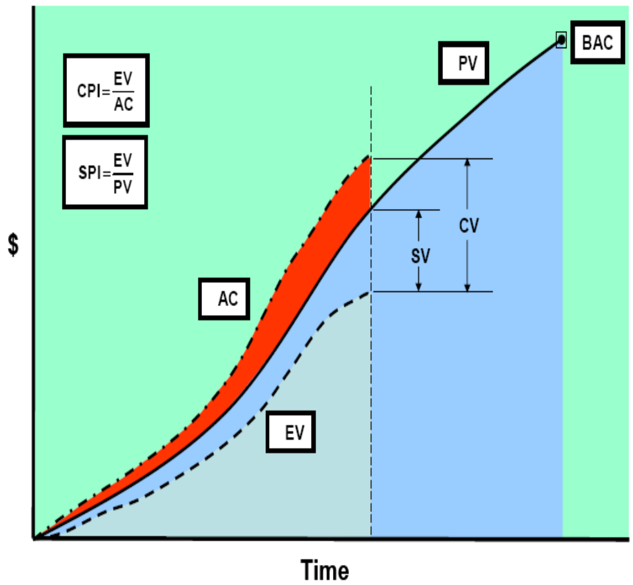

Figure 1: Earned value basics

Planned Value (PV): This is the cumulative planned cost for the work planned to be done on the project up to a given point in time. It is the approved budget for completing the work planned so far, and as such it is the cost baseline for the project. It was previously called the budgeted cost of work scheduled (BCWS).

Budget at Completion (BAC): This is the total amount of money expected to be spent on the project, and as such it is the value that PV is planned to reach at completion.

Actual cost (AC): This is the cumulative actual cost spent on the project so far, including all accrued cost on the work done. AC was previously called the actual cost of work performed (ACWP).

Earned value (EV): This represents the cumulative amount of work done up to a point in time, expressed in cost units. It is expressed as the amount that was planned to have been spent on the work that has been completed up to this point. EV was previously called the budgeted cost of work performed (BCWP). To calculate the EV for a given element of work, the planned cost is multiplied by the percentage complete. The EV for the project is the sum of the EV for all the work elements.

BAC, PV, AC and EV are expressed in cost units. That may be in units of actual money, in any currency. Or it can be expressed in hours or days of work done. PV, AC and EV can be calculated for any element of work to determine progress on that element of work

Project Performance Measurement:

Cost performance on the project is determined by comparing EV to AC. AC represents what has actually been spent and accrued to do the work so far, and EV represents what was planned to be spent to do the work so far.

The difference shows whether the project is over spent or under spent. Schedule performance is determined by comparing the EV to the PV. PV shows the amount of work that was planned to have been done and EV represents the amount that has been done. By comparing the two, we can determine whether more or less work has been performed than should have been done, and whether the project is ahead of or behind schedule. We do these comparisons by calculating variances and the performance indices.

Variances

The following formulas are used to calculate the variances:
The cost variance (CV) is a measure of cost performance:
CV = EV -AC

4. Earned Schedule

Earned schedule (ES) is an extension to the theory and practice of earned value Management (EVM). As of 2005, Earned schedule is designated as an "emerging practice" by the Project Management Institute. It was introduced in 2003 a seminal article "Schedule is Different" by Walter Lipke, in the measurable news, the quarterly magazine of the College of Performance Management, of the Project Management Institute. Lipke is the first who clears the concept on earning in terms of time.

According to Lipke, EVM tracks schedule variances not in units of time, but in units of currency (e.g. dollars) or quantity (e.g. labour hours). Of course, it is more natural to speak of schedule performance in units of time, subsequently, when a project is completed, its SV is always zero, and SPI is always one, even if the project was delivered unacceptably late.

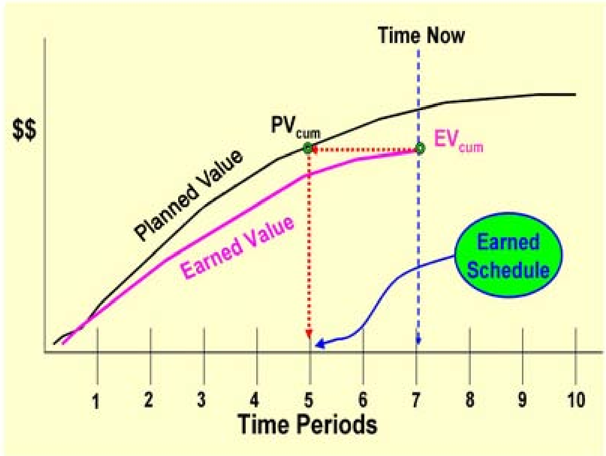

Figure 2: Earned schedule basics

Actual Time (AT): This is the duration from the beginning of the project to status date.

Schedule at Completion (SAC): This is the original planned completion duration of the project.

Earned Schedule (ES): This is the duration from the beginning of the project to the date on which PV should have been equal to the current value of EV.

ES = % Complete x SAC

Time Variance (TV): The Time variance is a measure of schedule performance in time units rather than cost units.

TV = ES – AT

If this value is negative the project is behind schedule, and if it is positive it is ahead of schedule. This is called schedule variance (time) SV (t).

Time Performance Index (TPI):

TPI = ES / AT

This is called schedule Performance Index (time), SPI(t), if TPI is greater than 1.0, the project is ahead schedule, and if it is less than 1.0, the project is behind schedule.

Forecasting of Time at Completion:

TEAC = SAC / TPI

This is gives the time estimate at completion with the same rate of doing work for the rest of the project.

Time Variance at Completion (TVAC):

The time variance at completion gives an indication of the estimated amount of time that the project will be completed ahead or behind schedule.

TVAC = SAC – TEAC

In this equation, 0.0 indicates that the project is expected to complete on schedule, a positive value indicates that the project is expected to be completed ahead of schedule and a negative value indicates that the project is expected to be completed behind schedule.

5. Case Study

The following case study illustrates the concepts discussed in this paper. Consider a construction of 41 6m sky walk. According to your plan the cost of construction will be ₹7.97 Cr and will take 6 months to complete.

Three months into the project, you have spent ₹5 Cr and completed 18 0m of sky walk, and you want to report performance.

Using the EVM Method:

BAC = ₹7.97 Cr
AT = 3 months
AC = ₹5 Cr

PV = 50% x ₹7.97 Cr = ₹ 3.99 Cr

EV = 40% x ₹7.97 Cr = ₹ 3.43 Cr

Therefore:

% Complete = EV / BAC = 43%
% Spent = AC / BAC = 63%

Cost and Schedule Variances:

CV = EV – AC = - ₹ 1.57 Cr

SV = EV – PV = - ₹ 0.53 Cr

Performance Indices:

CPI = EV /AV = 0.69
SPI = EV / PV = 0.87

Estimate at Completion and Variance at Completion

EAC = BAC / CPI = ₹ 11.55 Cr
VAC = BAC – EAC = - ₹ 3.58 Cr

Earned Schedule:

SAC = 6 months
AT = 3 months

ES = % Complete x Schedule at Completion
= 43% x 6 months
= 2.58 months

TV = ES – AT = -0.42 months
TPI = ES / AT = 0.86 months
TEAC = SAC / TPI = 6.98 months
TVAC = SAC – TEAC = -0.98 months

6. Result and Discussion

From the above equations, extra cost is required to complete this projects is ₹ 3.58 Cr as well as from earned schedule analysis extra time required to complete the project is 0.98 months.

Here, we can conclude that this project is in seriously trouble regarding both cost and schedule performance. Corrective actions required to be taken to complete this project within given cost and time.

7. Conclusion

Earned Value Management is a powerful methodology that helps executive, project manager, program manager and other stakeholders of the project to manage the project more effectively. Earned Schedule is an important extension to EVM that allows EVM metrics to be transformed to time or duration metrics to enhance the evaluation of project schedule performance, forecast the duration needed to complete the project. It helps the project managers to understand the time estimates for the completion of the project, and provides further insights for making better decisions about the project schedule and other critical parameters.

Earned Schedule has become a powerful new dimension which gives independent estimates of time with the help of earned value data in terms of time. The application of earned value and earned schedule tools for late finishing construction projects gives better predictions.

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