NAC Executive Insights

Earned Schedule

Key Points

- Earned Schedule (ES) is analogous to the Earned Value Measurement System (EVMS), a widely accepted system throughout the construction industry, except ES utilizes time versus cost to measure schedule performance.
- EVMS, which utilizes Planned Value versus Actual Value when assessing schedule performance, performs well for cost but is lacking with respect to schedule performance.
- Earned Schedule addresses the performance issue created by EVMS.
- One desirable attribute of ES is it builds on the already available EVMS data.
- Schedule variance does not become 0.0 at project completion, but instead reflects actual schedule performance.
- Schedule Performance Index (SPI) does not become 1.0, indicating perfect schedule performance at the end of every project, but rather reflects actual project schedule performance.
- ES metrics provide a better assessment of project performance against schedule as the project progresses.
- ES is the best method for forecasting project duration.
- Assessment of critical path performance versus overall project schedule performance is possible as is performance for bid-items cross-linked to schedule activities.
- Activities ahead of ES may represent activities at risk of significant rework in the future.
- Assessment of multiple critical or near critical paths improves overall schedule forecasting.
- ES facilitates assessment of high and low confidence limits, which can be used to forecast project duration.

Introduction

Earned Schedule as described in this Executive Insight complements traditional earned value measurement. The Earned Value Measurement System (EVMS) is a widely accepted and widely used throughout the construction industry and provides an effective tool for measuring cost. It also is often used to measure schedule, with the schedule measured in terms of dollars, not time. The traditional schedule performance measures of EVMS calculate Schedule Variance (SV) as Earned Value (EV) minus Planned Value (PV) and the Schedule Performance Index (SPI) as Earned Value (EV) divided by Planned Value (PV). Table 1 compares the cost and schedule measures under EVMS.

Table 1. EVMS Performance Measures		
Parameter	**Cost**	**Schedule**
Variance	CV = EV-AC	SV = EV-PV
Performance Index	CPI = EV/AC	SPI = EV/PV
Notes:	CV – Cost Variance EV – Earned Value AC – Actual Cost CPI – Cost Performance Index	SV - Schedule Variance PV – Planned Value SPI – Schedule Performance Index

While EVMS performs well for cost, it has been found to be lacking with respect to schedule performance. This was highlighted for the author on a major national program with dozens of individual projects where all completed projects showed 0.0 schedule variance and a SPI = 1.0. This is the inevitable outcome of these parameters on all projects using the original formulations for schedule performance measurement under EVMS. Additionally, depending on the shape of the planned project execution profile and where one is in overall execution, these traditional EVMS schedule measures can be misleading.

Earned Schedule

To address these shortcomings in traditional EVMS measurement of schedule performance, the concept of Earned Schedule (ES) was developed.[1] ES is analogous to EVMS except ES utilizes time versus cost to measure schedule performance. ES addresses the performance issue created by EVMS utilizing Planned Value versus Actual Value when assessing schedule performance. Under the Earned Schedule[2] approach, cost and schedule performance is measured comparably against *actual* values for cost (AC) and time (AT).

Earned Schedule, utilizing time, then can be measured as:

- Schedule Variance: SV(t) = ES-AT
- Schedule Performance Index: SPI(t) = ES/AT

A positive schedule variance indicates a project is ahead of schedule, while a negative schedule variance indicates schedule performance is lagging. An SPI is greater than 1.0 when a project is ahead of schedule and less than 1.0 when performance is lagging. At project completion, SV(t) does not become 0.0 unless perfect execution has been achieved. Similarly, SPI(t) does not become 1.0. True schedule performance is not a mathematical convenience.

[1] Lipke (2003); Henderson (2004)
[2] Now included in the *Project Management Book of Knowledge* (PMBOK)

Calculating Earned Schedule from EVMS

Figure 1[3] illustrates the difference between schedule variance calculated based on cost (SV) and time (SV(t)).

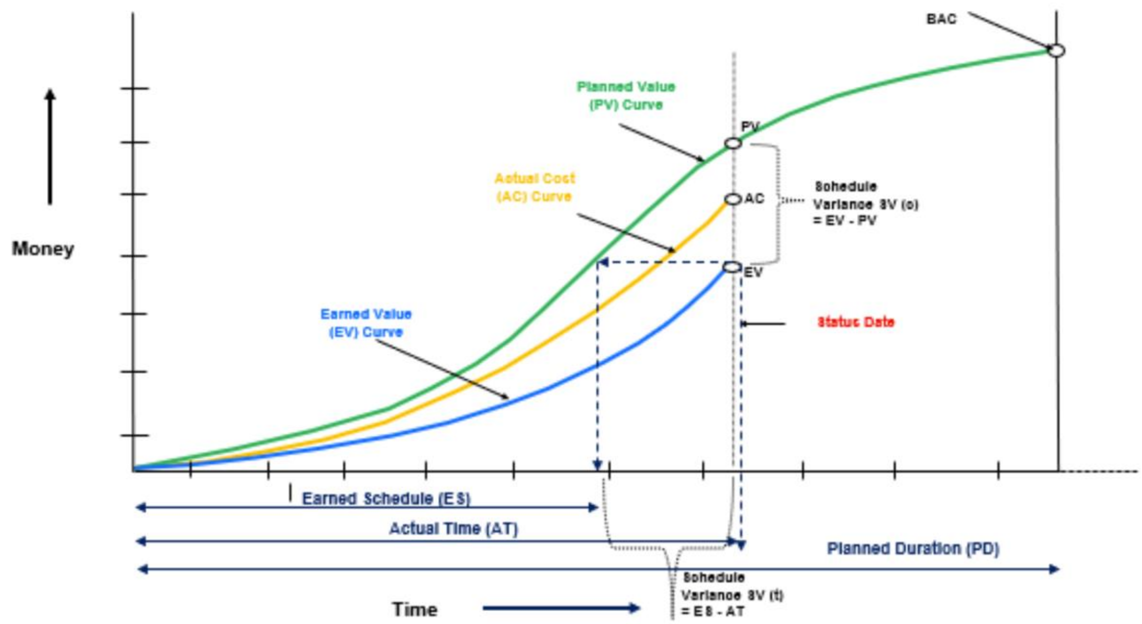

Figure 1. Difference between schedule variance calculated based on cost and time

In Figure 1, the traditional EVMS definition is shown, that is, Schedule Variance (SV) = EV-PV.

Schedule Variance utilizing the Earned Schedule approach, SV(t), is also shown, where Earned Schedule (ES) is the original point in time associated with the current (actual time (AT)) Earned Value (EV). This yields SV(t) = ES-AT.

One of the desirable attributes of Earned Schedule is that it builds on the already available EVMS data. The accuracy of EVMS and ES analysis depends on the effort invested in creating the PV curve, which is the traditional S-curve seen in most cash flow projections. Most of the time, these cash flows or Planned Values (PVs) are based on an early version of a schedule. Since the ES is dependent on the EV and the horizontal intersect line with the PV, where that curve tracks will have tremendous impacts on the outcome of each analysis. High-cost purchases traditionally put a strain on the PV because they provide a false sense of security of being on schedule. In reality, the high-risk portions of the work, labor, and productivity will have a much greater influence on the outcome of the project than the high-cost purchases.

[3] https://www.mpug.com/earned-schedule-management-esm/

The construction schedule and cost projections should be made on a bid package basis and rolled up into a summary PV. This will make it much easier to measure schedule and cost as the project progresses.

Advantages of Earned Schedule

A few of the advantages of ES to measure project schedule performance, previously described, are:

- Schedule Variance does not become 0.0 at project completion, but instead reflects actual schedule performance.
- Schedule Performance Index (SPI) does not become 1.0 (indicating perfect schedule performance at the end of every project), but rather reflects actual project schedule performance.
- ES metrics provide a better assessment of project performance against schedule as the project progresses.

Earned Schedule also provides some additional advantages:

- **Best method of forecasting project duration**:
  - Independent Estimate at Completion (Forecast Duration) (IEAC) = Planned Duration (PD)/ SPI(t)
- **Assessment of likelihood on achieving a specific going-forward project duration** described as the To Complete Schedule Performance Index (TSPI):
  - TSPI = (PD-ES)/ (TD-AT), where TD is the total duration desired
    - When TSPI ≤1.00, the Total Duration (TD) desired is likely achievable.
    - When TSPI ≥1.10, achieving TD is not likely.
- **Assessment of critical path performance versus overall project schedule performance**:
  - Uses just the EV for activities comprising the critical path.
    - Highlights any imbalance between critical path and non-critical path activities.
    - Future execution problems are more likely to arise.
  - When SPI(t) for the project exceeds that of the SPI(t) for critical path, it is indicative of the project not performing synchronously with activities on the critical path, lagging scheduled performance even while other activities may be ahead of schedule.
    - Lags in critical path activities may be indicative of barriers to execution that may not yet be fully resolved.
    - Activities ahead of Earned Schedule for the project may represents activities at risk of significant rework in the future.
- **Assessment of multiple critical or near critical paths improves overall schedule forecasting** as Earned Schedule has been shown to be more accurate for schedules that are more serial than parallel.

    - The longest forecast is typically the most representative and should converge the fastest as the project progresses.
- **Facilitates assessment of high and low confidence limits of SPI(t) that can be used to forecast project duration**. The three forecasts, SPI(t) and its high and low statistical variations, should converge as work progresses, allowing the three Independent Estimates At Completion (IEAC) to be calculated as PD/SPI(t), where the appropriate SPI(t) value is used.
    - The flattest IEAC plot over time tends to be the best predictor of final project duration.

Summary

Earned Schedule (see Table 2 below) represents an important extension of the EVMS approach. In large programs comprising multiple projects, Earned Schedule performance provides a better measure of overall program management effectiveness when compared to schedule performance assessed on a cost basis by EVMS. The ability to consider performance at the project or bid package level provides added insight and supports effective management. After all, the devil is in the details.

Table 2. Earned Schedule

Parameter	**Definition**
EVMS	Earned Value Management System
ES	Earned Schedule; original point in time associated with the current (actual time (AT)) Earned Value (EV)
EV	Earned Value at actual time
AC	Actual Cost at actual time
PV	Planned Value at actual time
CV	Cost Variance (EV-AC)
CPI	Cost Performance Index (EV/AC)
SV	Schedule Variance (EV-PV); cost basis
SPI	Schedule Performance Index (EV/PV); cost basis
AT	Actual Time
SV(t)	Schedule Variance (ES-AT); time basis
SPI(t)	Schedule Performance Index (ES/AT)
PD	Planned Duration
IEAC	Independent Estimate at Completion (PD/SPI(t)); best method for forecasting project duration
TD	Total Duration desired
TSPI	To Complete Schedule Performance Index ((PD-ES)/(TD-AT)); likelihood of achieving specific going forward project duration

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.