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Forecasting Schedule Variance using Earned Schedule
by Walt Lipke
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Forecasting Schedule Variance Using Earned Schedule

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Abstract

The application of Earned Value Management (EVM) provides insight to a project's performance, thereby providing management information useful for project control. Many projects, especially those that are large, establish milestones in their schedules. Milestones are used to assess progress, usually by evaluation of product characteristics, at an interim point significant to the project. Although EVM plays a role, the method is not focused on milestone achievement. To address this perceived void, this paper introduces an Earned Schedule method for determining, in process, the achievability of a specific milestone.

Introduction

EVM and ES provide management information about current performance; i.e., performance efficiency and variance from the cost and time estimates comprising the project's performance baseline. As well, the two methods are used to forecast the cost and duration at project completion. EVM and ES are oftentimes applied to components of a large project to provide more management granularity. The categories of management information, derived for project components, are identical to the total project; i.e., performance efficiency, variance, and end-point forecasts. In this mode, the EVM/ES approach does not provide an assessment regarding achievement of a project milestone.[1]

Assessing milestone achievement through the application of EVM and ES is somewhat of a mind-twist. The assessment desired is different from their current use. That is, it is not for present or past status periods, nor for project completion. Rather, the analysis interest, the milestone, is scheduled at a time in-between the two. This difference is significant and raises the question:

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[1] For this paper, the term "milestone" is intended as a generic term, interpreted as any event important to the project that has dependence upon achievement of earned value.

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Using EVM/ES methods, is assessment of milestone achievability possible?

Describing the approach, the calculations, and methods is the goal of this paper. Hopefully, by the conclusion the answer will be recognized, "Yes, it can be done."

Earned Schedule Review

Earned Schedule is dependent upon EVM; the ES measure is derived from the accrued earned value (EV) and the performance measurement baseline (PMB) [Lipke, 2003]. As shown in figure 1, "the idea is to determine the time at which the EV accrued should have occurred." The time duration from project start to the point on the PMB where the planned value (PV) equals the EV accrued is the earned portion of the planned duration (PD), i.e. ES.

As diagrammed in the figure, determining the value of ES is a simple matter of interpreting the graph. In practice, however, a calculation method is applied. Its description is explained, in detail, in the *Earned Schedule* book [Lipke, 2009]. As well, to simplify and encourage usage the *ES Calculator* spreadsheet is freely downloadable from the ES website.[2] Additionally, commercial EVM tools provide ES analysis capability.[3]
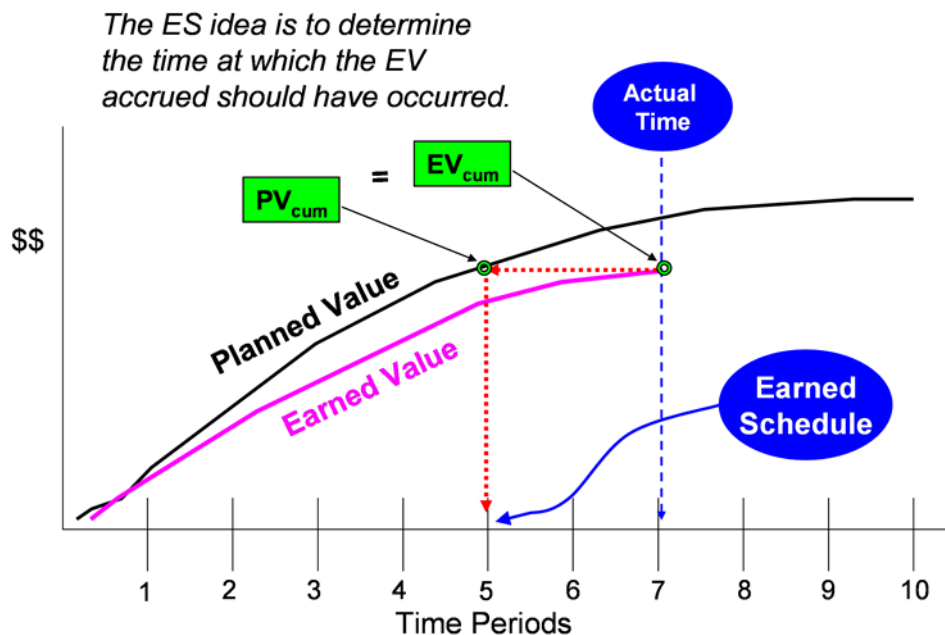

Figure 1. Earned Schedule Concept

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[2] The ES website URL is www.earnedschedule.com.
[3] Refer to the EVM Tools page of the ES website.

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Having the capability to determine ES and the actual time (AT) at which the EV is reported, the time-based indicators for schedule performance index, SPI(t), and schedule variance, SV(t), are created:

$$SPI(t) = ES / AT$$
$$SV(t) = ES - AT$$

The index, SPI(t), describes the efficiency of achieving the PD for the time invested. When the value of SPI(t) is 1.0 or greater, schedule performance is good. And, when the indicator value is less than 1.0, performance problems need investigating and correcting. Similarly, when the value of SV(t) is positive, performance is ahead of schedule and when negative, performance is lagging.

Beyond assessing current status, the forecasting of project duration and completion date is made possible using the formulas below:

$$1)\ IEAC(t) = PD / SPI(t)$$
$$2)\ IEAC(t) = AT + (PD - ES) / PF(t)$$

IEAC(t) is the independent estimate at completion (time), i.e. the forecast duration; adding the computed duration to the project start date can be used to forecast the completion date. The PF(t) term, appearing in formula 2, is a performance factor; for example, SPI(t) for the last three performance periods could be used when believed it better represents the expected future execution efficiency.[4]

The creation of ES also provides facility for determining the performance efficiency required to complete the project within the PD, an estimated or desired duration (ED), or specified date. The to complete schedule performance index (TSPI) is defined as follows:

$$TSPI = (PD - ES) / (PD\ or\ ED - AT)$$

The values computed at each project status point for IEAC(t) and TSPI provide very good management information. It is well established that ES yields reasonably good project duration forecasts that improve with project progress. [Vanhoucke et al., 2007] [Crumrine et al., 2013] [Lipke, 2015] Recently, research of TSPI, using real data, has shown that when the value of the indicator exceeds 1.10 the likelihood of completing the project on time is very low. [Lipke, 2016]

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[4] Recent research has shown that PF(t) = 1.00 provides reasonable forecasts. [Vanhoucke et al., 2015].

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Milestone Assessment

It is an interesting problem:

Just how can SPI(t), SV(t), IEAC(t), and TSPI be evaluated for a milestone?

Assessing performance for milestone achievement is similar to the ES application to critical path (CP) analysis. [Lipke, 2006] To analyze performance for the CP, its performance baseline is required. From the schedule and the estimated values of cost and duration for the tasks comprising the CP, the associated PMB can be created. Having the baseline, ES analysis of the CP can be performed just as for the project.

Milestone analysis capability is created in the same manner. The project tasks specifically required for milestone success are identified and used to prepare its performance baseline, i.e. PMB_M. Just as for the CP, once the performance baseline is established, analysis is facilitated for milestone achievement.

To differentiate the EVM and ES measures associated with the milestone baseline, they are given the subscript "M": PV_M, EV_M, and ES_M. As well, the milestone schedule performance indicators use the "M" subscript to separate them from those for the project:

$$SPI(t)_M = ES_M / AT$$
$$SV(t)_M = ES_M - AT$$

Additionally, the forecasting and prediction formulas require modification for milestone application. Instead of project completion, the determination is for the milestone of interest. Thus, the duration used in the formulas must change from the project (PD) to the milestone duration (MD). Substituting MD for PD, the formulas become:

1) $IEAC(t)_M = MD / SPI(t)_M$
2) $IEAC(t)_M = AT + (MD - ES_M) / PF(t)$
3) $TSPI_M = (MD - ES_M) / (MD \text{ or } ED_M - AT)$

where ED_M is the estimated or desired milestone duration.

Usually, the milestone duration will not coincide with the conclusion of a status period. Thus, as a general case, it will have a value that is not an integer.

Because the durations associated with milestones are at interim points within the project, a forecast schedule variance is reasoned to have good management utility. The forecast indicates how many days the project is ahead or behind at the scheduled

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duration of the milestone. As well, the project manager knows the amount of calendar time between now and the milestone date; i.e., the window of opportunity to correct or make use of the forecast variance.

The forecast schedule variance, F-SV(t), for a milestone is computed using the following formula:

$$F\text{-}SV(t) = MD - IEAC(t)_M$$

As can be deduced, when $IEAC(t)_M$ is greater than MD, F-SV(t) will be negative, indicating the milestone may not be achieved at the planned time. And, of course, when F-SV(t) is positive the expectation is milestone success.

A milestone may have planned a number of days of slack, for which completion within that short period is acceptable. A manager desiring information about milestone achievement within the slack period could substitute ED_M for MD in the F-SV(t) expression, where

$$ED_M = MD + number\ of\ days\ of\ slack$$

Milestone Analysis Example

For the example, let's assume weekly status periods. The period preceding the milestone date is number 18; the milestone date is set for 4 days after period 18 with slack equal to one day. The project is planned for completion in 27 periods. Thus far, there have been 13 periods of execution.

Figure 2 shows the computed values for the indicators, F-SV(t) and $TSPI_M$. $IEAC(t)_M$ equation 1 was used to calculate the duration forecasts. As observed, there is general improvement for both indicators. In an average sense, each is better over the last six periods as compared to values during weeks 1 through 7.

Period	1	2	3	4	5	6	7	8	9	10	11	12	13
F-SV(t)	-8	-45	-13	-16	-12	-4	-9	-5	1	1	0	-5	-2
$TSPI_M$	0.996	1.023	1.010	1.022	1.022	1.005	1.032	1.019	0.988	0.985	0.993	1.053	1.024

Figure 2. Milestone Analysis

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At week 13, F-SV(t) indicates the project will miss the milestone by two days, including the one day of slack; without the slack, the variance would be minus three days. The $TSPI_M$ value of 1.024 lets the manager know that, with proper action, it is possible the two days can be recovered within the next five periods and the milestone met.

Calculation Aid

A calculation aid has been created, easing the effort of milestone performance analysis. The Excel spreadsheet, _ES Calculator – Milestone SV(t) Forecast_, is available for download from the Calculators page of the ES website.

A cropped screenshot of the Milestone Forecast worksheet is shown in figure 3. It is the calculation results for the analysis example discussed in the previous section. For those familiar with ES, you will note, when viewing the full worksheet, that the portion of the spreadsheet to the left of the Period column has been taken from the basic _ES Calculator_. Fundamentally, if you are already using the _ES Calculator_, expanding to milestone performance assessment should be a simple matter.

Period	Status Date	Milestone	F-SV(t)	Perf-Fac	Conv-Days	$TSPI_M$
	mo/da/yr		days	S or V	M, B, or W	
1		6/1/2017	-8	S	W	0.996
2		**Milstn Date**	-45		**Conv-Days**	1.023
3		6/5/2017	-13		7.00	1.010
4		**Milstn Duration**	-16			1.022
5		18.6	-12			1.022
6		**Milstn Slack (da)**	-4			1.005
7		1	-9			1.032
8		**Status Period**	-5			1.019
9		18	1			0.988
10			1			0.985
11			0			0.993
12			-5			1.053
13			-2			1.024
14			F-SV(t)			TSPlm
15			F-SV(t)			TSPlm
16			F-SV(t)			TSPlm
17			F-SV(t)			TSPlm
18	6/1/2017		F-SV(t)			TSPlm
19			F-SV(t)			TSPlm
20			F-SV(t)			TSPlm

Figure 3. Calculation Aid Screenshot

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The milestone analysis calculator includes an Instruction sheet as well as an Example Data & Results (ED&R) sheet to encourage familiarity and understanding. The ED&R sheet contains trial data and computed results. The worksheet also includes a Notes insert, providing definitions for the terminology used.

Summary

EVM and ES are constructed to provide management information useful for project control. As presently employed, they do not directly assist managers in the achievement of project milestones.

Using the general concepts of EVM and ES, methods are developed for computing milestone duration and schedule variance forecasts, IEAC(t)$_M$ and F-SV(t), respectively. As well, the to complete schedule performance index is adapted for milestone management, i.e. TSPI$_M$. The methods created are generally applicable to any event, important to the project manager or customer, that has dependence upon the achievement of earned value.

A milestone management example is presented, illustrating the combined use of the forecast schedule variance, F-SV(t), and TSPI$_M$. The resolute nature of the forecast variance is shown to provide increased management utility.

The calculation aid, *ES Calculator – Milestone SV(t) Forecast*, has been created to assist managers in their effort to achieve milestone success. The calculator is available for download from the ES website.

Acknowledgment

Recently, I was contacted by a person interested in applying ES to his project. During the email exchanges, he presented an application approach that had me somewhat confused. After pondering his approach, I asked the question, "Are you attempting to see if you can achieve a project milestone?" He confirmed that was the objective. Subsequently, I created and provided a spreadsheet that fit his application.

Afterward, upon reflection, I reasoned that milestone management through the application of EVM and ES may have interest, especially to those managing large projects. This article and the spreadsheet introduced are the result of my contact with Mr. Duncan Forsyth. Mr. Forsyth of Atlas Business Services, Inc. is a program manager, presently supporting government oversight of an extremely large Department of Energy

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nuclear facilities construction project. Mr. Forsyth has expressed willingness to discuss his approach to milestone management. He can be contacted at djf@atlasbizsvcs.com.

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Walt Lipke retired in 2005 as deputy chief of the Software Division at Tinker Air Force Base, where he led the organization to the 1999 SEI/IEEE award for Software Process Achievement. He is the creator of the *Earned Schedule* technique, which extracts schedule information from earned value data.

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- PMI Eric Jenett Award (2007)
- EVM Europe Award (2013)
- CPM Driessnack Award (2014)

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