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Forecasting Project Schedule Completion With Earned Value Metrics

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In the Glossary of the 2000 edition of the PMBOK® Guide, Earned Value Management (EVM) is defined as, "*A method for integrating scope, schedule and resources, and for measuring project performance.*" Although this definition implies equal weight to both cost *and* schedule, the reality is that most of the widely accepted and useful EVM computations focus primarily on cost. Consider the forecasting metric, Estimate at Completion (EAC). This computation strictly deals with forecasting the probable outcome of costs. At this time there is no generally accepted counterpart to EAC for forecasting the probable outcome of project schedule.

The purpose of this paper is to demonstrate a viable methodology for forecasting project schedule using earned value metrics; and to solicit comments and critique regarding the viability of incorporating them to complement the existing set of EVM definitions and formulas. In this context, we will examine existing concepts and introduce new ones to support the thesis that definitive schedule predictions, using earned value metrics, can be readily attained and universally applied.

One may argue that EVM practice *does* include cost and schedule variances (CV and SV respectively) as well cost and schedule performance indexes (CPI and SPI respectively). The CV calculation, which compares the difference between the earned value (EV) and actual cost (AC), provides an accurate degree of specificity regarding cost performance. The CV calculation determines exactly how many Work Units[1] were *spent* versus how many work units were *earned*. At some point in project execution, if EV<AC, we have a negative or overrun condition. Unless draconian measures are taken to *earn* more than is *spent* for the remainder of the project, the originally calculated CV typically will not change for the better. As such the value of the CV when added to the budget (or budget at completion, or the BAC) is one possible predictor of the estimate at completion (EAC) for the project. This can be borne out in one of the accepted practices of calculating EAC, which is:

EAC = (Work Remaining) + AC = BAC – EV + AC

Since CV = EV– AC, we may algebraically rewrite the above equation as:

EAC = BAC – CV

(Recognize that a negative CV *adds positively* to the BAC.)

On the other hand, the schedule variance

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(SV), which compares the difference between the earned value (EV) and planned value (PV)2 , does not correspondingly provide a similar degree of specificity for schedule performance. First, the value of SV is expressed in cost or Work Units, rather than time or duration units. Since we intuitively relate the word "schedule" to time, the utilitarian value of the SV calculation is not an easy concept to grasp. About the only meaning one can derive from SV is a relative one. If SV is negative (EV<PV), we are behind schedule and if positive, ahead of schedule. Beyond this relative measure, plus comparing it to CV (to determine which is worse or better, cost versus schedule variance), it does *not* possess the strong predictive virtues of the CV calculation. Secondly, since the value of SV reverts to zero at the end of the project, it has no utility for estimating the duration at completion. However, as we will develop, the schedule performance index (SPI)[3] does have utilitarian value in forecasting the duration. The SPI is a pure number. In mathematical parlance, a pure number does not have "dimension", such as meters, lumens, dollars, hours, etc. If SPI<1 for a given activity, it indicates that its slipping in schedule.

Forecasting Activity Duration

The following proposed formulas can be used to forecast the duration of an activity at a specific point in time during the project life. We call these the Estimate of **D**uration at **C**ompletion **(EDAC).** These formulas can be used for any activity and have particular merit in analyzing those activities on the critical path.

The generic formula is:

EDAC = [(Duration Remaining) ÷ (Performance Factor)] + Duration Variance

Where:

1. **Duration Remaining (DR)** is the difference between the **P**lanned **D**uration **(PD)** of a specific activity and the **A**ctual **D**uration **(AD)** of a specific activity at some point in time, but before completing the activity, or

   DR = PD – AD.
   Important — *if PD<AD, then DR = 0. DR can be only zero or positive.*

2. **Performance Factor (PF)** provides two possible values, which gives us a range for forecasting **EDAC:** The two cases for the **PF** are:
   a. **PF = 1**, *which assumes that the rest of the activity will be done at 100 % schedule efficiency; or SPI = 1*. We call this the "low EDAC" or **$EDAC_L$**.
   b. **PF = SPI,** *which assumes that the rest of the activity will be done at the currently calculated value for SPI.* We call this the "high EDAC" or $EDAC_H$.

3. Duration Variance is the ratio of the **AD** to the **SPI** for that activity, or

$$DV = AD \div SPI$$

Thus we have the two possible EDAC calculations as follows:

$$\mathbf{EDAC_L = [(PD - AD) \div (1)] + DV,}$$
(where PF = 1)

and

$$\mathbf{EDAC_H = [(PD - AD) \div (SPI)] + DV,}$$
(where PF = SPI)

Utilizing these EDAC formulas is best shown in the following example:

Sample Calculations Using EDAC to Forecast Activity Duration

Problem

An activity has a 4-week duration and a budget of 400 work units (WU). The planned expenditure is linear, at 100 work units per week. The EV measurement method will be "percent complete". Thus we have a budget (BAC), planned duration (PD), and a cumulative planned value (PV), where Week #1 = 100 WU, Week #2 = 200 WU, etc.

At the end of the first week, it is reported that we are 20 % complete. What is the forecasted duration range for completing this activity?

Solution

The **EV** = 20% X 400 = 80 WU.
The **PV** (at the end of the first week) = 100 WU.
The **SPI** = EV ÷ PV = 80 ÷ 100 = 0.8, *indicating that this activity is behind schedule since SPI<1.*
The **PD** = 4 weeks.
The **AD** = 1 week.

Case #1 — Assume that, for the *rest* of this activity, we expect to revert to plan.
(Or PF = SPI = 1). We can then compute **$EDAC_L$** as:

$$\mathbf{EDAC_L = [(4 - 1) \div (1)] + [1 \div 0.8] = \underline{4.25\ weeks}}$$

Case #2 — Assume that, for the *rest* of this activity, we expect to sustain performance at the currently computed SPI = 0.8. We can then compute **$EDAC_H$** as:

$$\mathbf{EDAC_H = [(4 - 1) \div (0.8)] + [1 \div 0.8] = \underline{5\ weeks}}$$

Thus we have forecasted a range of duration outcomes for this

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activity — 4.25 weeks to 5 weeks. As practitioners of EVM, we recognize that there is no sanctity in the numbers themselves. Rather, it is *how* best to use them to make intelligent decisions regarding the needed corrective action to bring about project success.

For instance, if this activity were on the critical path, we can readily see that the project will be anywhere from 0.25 to 1-week late, basis the original plan. If schedule is the driving constraint, then we must invoke measures such as *crashing* (shortening the duration of the remaining critical successor activities) or *fast tracking* (changing the schedule network by overlapping activities). On the other hand, if this activity were non-critical, one should examine how much of the total float is used, and thereby how much attention, if any, should be devoted to corrective action for this and its successor activities.

Test For Universality of the EDAC Formulas

In the above example we applied the EDAC where the activity "straddled" the reporting time-period. In other words the activity is still in progress. The proposed EDAC formulas can be tested for universality in all cases by examining the situation where the reporting time-period is at the end of the 5th week. Let us further assume the SPI of the activity remains at SPI = 0.8, indicating it is not completed as planned. In fact, in qualitative terms this activity is well past due. The following parameters are used in this case:

PD = 4 weeks AD = 5 weeks SPI = 0.8

Then:

$$\mathbf{EDAC_L = [(4 - 5) \div (1)] + [5 \div 0.8]}$$

And

$$\mathbf{EDAC_L = 0 + [5 \div 0.8] = \underline{6.25\ weeks}^{*}}$$

* *In this case, since PD<AD, then DR = 0 and there is only one EDAC that we can compute.*

Calculations show this activity is forecasted to require an additional 2.25 weeks beyond its originally planned completion date of 4 weeks. As discussed previously, one must examine what impact this activity (whether critical or non-critical) has on the entire project.

When or How Often Should EDAC be Applied ?

In mature project management practices, there is always a delicate balance between providing meaningful performance reporting data, but without creating an unnecessary administrative burden. Typically the Control Account Plan (CAP) is the level in the work breakdown structure (WBS) where EV for cost performance reporting takes place. This is a level above the Work Packages subordinate to their respective CAP's. Reporting at the CAP level is prudent when performance is going tolerably well. However, when things are going poorly it is incumbent to "mine" down to lower levels to determine the root cause of the problem.

When applying EDAC metrics, the schedule (rather than the WBS) becomes the principal instrument to monitor. Typically, a Gantt or bar chart (ideally derived from a network diagram, which has established those activities on the critical path and those that have float) represents the schedule. When progress is not going as well as planned, one should obviously apply EDAC metrics to those individual activities with SPI's less than one (1); and are to the left of or straddling the reporting time-period. Those activities on the critical path should be scrutinized first, since EDAC metrics will forecast a possible slip of the overall project duration. A close second are those that are at high risk in meeting project objectives. A third are those that are threatening to use most of the total float for a given path.

In conclusion, EDAC metrics provides a powerful "early warning" tool for forecasting schedule completion, and is a useful complement to EAC metrics for forecasting cost.

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[1] A Work Unit is a generic description of cost, which can be characterized as monetary units (dollars, pounds, yen, etc.) or hours of effort.

[2] The PV (or BCWS) is a cumulative, time-phased planned rate of expenditure. The value of PV is unique for each point in the time-line of a project cycle. The PV and BAC are equal at the end of the project.

[3] The SPI is the ratio of EV to PV or SPI = EV/PV; correspondingly the CPI = EV/AC