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Time Is Up:
Assessing Schedule Performance with Earned Value

By Robert Van De Velde

Time drives projects. Quick and accurate evaluation of schedule performance is crucial. Quantitative assessment provides the PM and others with an objective measure of past performance and a reliable prediction of future performance. Earned Value has proven effective for evaluating cost performance, but it fails for schedule performance. A recent breakthrough, called Earned Schedule, corrects the problem and raises project time management to new prominence.

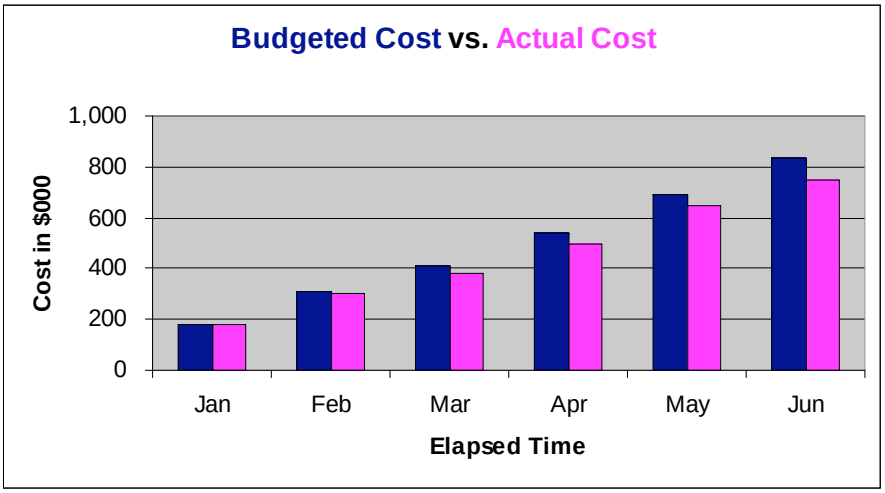
What is EVM?

Earned Value Management (EVM) is a technique for quantitatively assessing project performance. Simply put, EVM assigns a value to work that is planned (Planned Value, or PV) and that has been completed (Earned Value, or EV). Planned Value is the budgeted cost of the work to be performed. Earned Value is the budgeted cost of the work times the percent complete. Cost performance is measured by comparing EV and the actual cost of the work performed. Schedule performance is measured by comparing EV and PV.

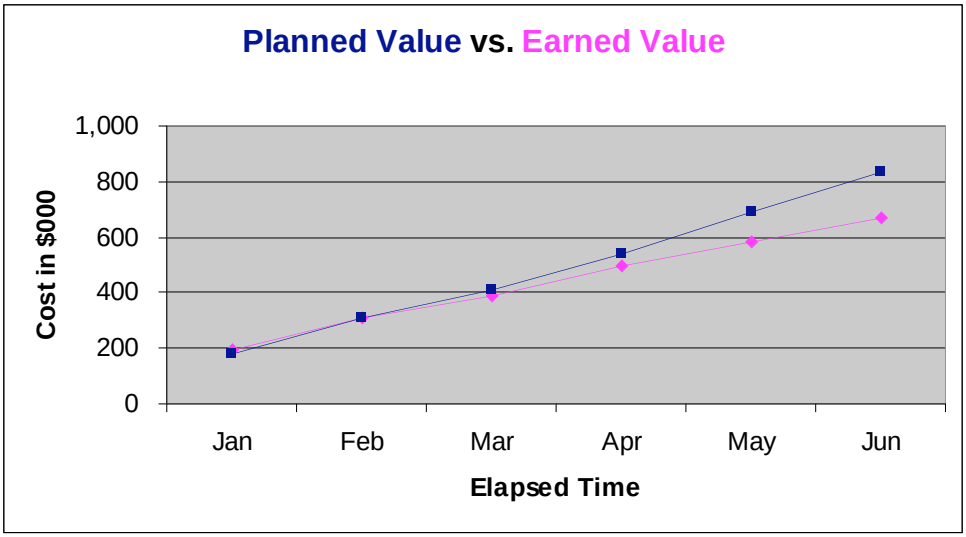
Details of these concepts have been developed over the past thirty years, supported by a host of mathematical formulas. As this article is oriented toward practical application, it focuses more on illustrations and everyday language than conceptual details and mathematics, although some theory and formulas are required.

Benefits of EVM

The following chart is a common representation of cost status on a project. It appears to show that project costs are tracking slightly below plan, and it seems reasonable to conclude that costs are not a concern.



The following EVM chart is based on the same underlying data, but it tells a different story.



The Earned Value is tracking below plan and, worse, the gap is widening. That means not enough value has been delivered for the money spent, and the situation is deteriorating. Additional EVM calculations show that the estimated cost at completion will be over budget.

The common representation is clearly uninformative, if not simply misleading. It lacks crucial information about how much should have been done for the cost expended. EVM fills in that information, showing the relationship between cost and time, plan and result.

Constraints of EVM

Studies have repeatedly shown that EVM is a useful technique for managing project cost.[1] EVM has not been as successful in assessing schedule performance. First, schedule performance is expressed in terms of cost, namely, Earned Value vs. Planned Value, rather than time, making

the measurements less intuitive. Worse, because schedule performance metrics compare EV and PV, they ultimately break down. At the end of a project the EV equals the PV, by definition. Consequently, a project that completes three months late shows zero variance between EV and PV and has a perfect schedule performance index (EV divided by PV).

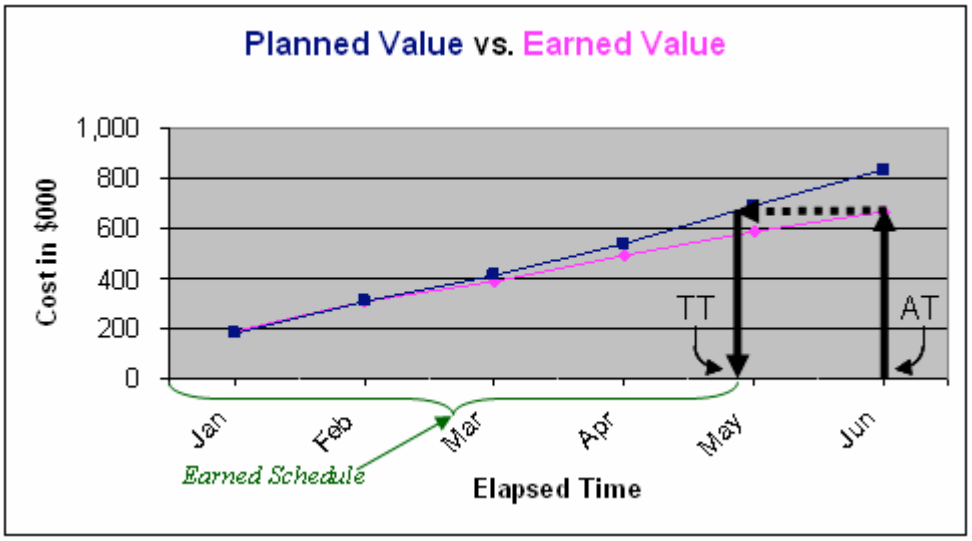
A misleading end state is bad enough, but the breakdown begins much earlier. After a project is about two-thirds complete, EVM schedule performance metrics become unreliable, as EV invariably converges on PV.[2]

The use of EVM to manage schedules has been inhibited by these constraints. Fortunately, a recent breakthrough goes a long way toward lifting them.

Earned Schedule

Over the past several years, research has been published on a new approach to assessing schedule performance.[3] The seminal idea was developed by Walt Lipke, while working for the U.S. Air Force. Lipke's approach utilizes EV and PV, but it relates them more directly to time. Lipke calls the metric, Earned Schedule. The idea is simple and elegant. The amount of time that is earned on a project is measured by correlating EV, PV, and timeline. Earned Schedule is then used not only to calculate status but also to predict future results.

Lipke's approach is illustrated with the following chart.



To find the Earned Schedule, determine the EV at the Actual Time (AT), i.e., the current date. Most scheduling tools automatically calculate this value. Next, map the EV onto the PV curve. This is simple to do. The EV has the same cost as the PV; so, just project a line from EV to the PV curve (see the dotted line in the chart).

The point where EV intersects the PV curve implies the amount of time that has been earned: drop a line from the intersection point to the timeline. This represents the amount of time it took to get to the PV at the intersection point. Call this the Target Time, TT.

Now, sum the time segments. Count the number of full periods between the project start and the Target Time. If TT is within a period, rather than aligned at a period end date, determine the fractional amount of time that has been earned. The ES is the total of the full time periods and the fractional amount (in the chart above, there are four full periods, Jan-Apr, and a fractional period in May).

The Fractional Amount

The calculation of the fractional amount is the only part of Lipke's approach that requires elaboration. The problem is that the Target Time is not known and cannot be directly calculated. So, there is no straightforward way to determine the fractional amount—it must, therefore, be approximated. Lipke's approximation uses corresponding, known values from the PV curve.

The PV at the start of the partial period is known, as is the PV at the end of the period. Planned Values are cumulative. Subtract the PV at the start from the PV at the end, and the amount of PV in the partial period is the remainder. This corresponds to the amount of time from the start to the end of the partial period.

Similarly, the PV at the start of the partial period and the PV at the Target Time are known. (Remember, the PV at TT is equal to the Earned Value at the Actual Time.) Subtract the PV at the start of the partial period from the PV at TT, and the amount of PV up to TT is the remainder. This corresponds to the amount of time it took to achieve the desired PV.

The fractional amount of the partial period is then calculated by placing the amount of PV up to TT over the amount up to the end. In this case, a formula makes it easier to see what is going on:

$$PV_{\text{Target Time}} - PV_{\text{Partial Period Start Time}} \;/\; PV_{\text{Partial Period End Time}} - PV_{\text{Partial Period Start Time}}.$$

In short, the fractional amount of time in the partial period is approximated by the fractional amount of Planned Value in the same period. (For a detailed explanation, see the Appendix.) Follow up studies have shown that the margin of error in the approximation is negligible.[4]

Earned Schedule Calculations

As stated previously, the total amount of ES equals the number of full periods plus the earned time in the partial period. Schedule variance is then defined as the difference between Earned Schedule and the Actual Time. As with cost variance in traditional EVM, a negative difference indicates that the project is behind schedule and a positive difference the opposite. Schedule performance is further assessed by calculating the ratio between ES and AT. Again, paralleling EVM, a schedule performance ratio (or index) less than one indicates problems and greater than one the opposite.

Unlike traditional EVM, Earned Schedule supports prediction of project duration and end date. The estimated duration of the project equals its planned duration divided by the schedule performance index. The projected end date is easily calculated by adding the estimated duration to the start date.[5]

Requirements for Implementing ES

The approach described above is not just a neat theory. It has actually been used to manage projects. What has emerged in doing so is a set of requirements for implementing Earned Schedule. The requirements first deal with generating the data needed for the ES calculations and then with performing the calculations themselves.

Assume that the Project Manager (PM) creates a schedule and uses a scheduling tool. Manual calculation of ES is possible, but onerous. It is unlikely that PMs will use ES without automated support. Given this assumption, the PM needs to take the following three steps to ensure good quality data for the calculations:

1. Maintain the Schedule: the schedule must be kept up-to-date. This sounds obvious, but many PMs create a schedule at the start of a project and then leave it untouched for the duration. For ES to work, take the schedule seriously. Track work that is done and that remains. When necessary, re-jig the whole schedule.

2. Set a Baseline: the system needs a basis for measurement, and the baseline provides it. Again, many PMs are reluctant to set a baseline, perhaps because it represents a visible commitment to dates. To get over the psychological hurdle, set a preliminary baseline early in the project and then re-set it later for publication. Modifying the baseline will affect the ES calculations, but that is better than not having a baseline at all.

3. Enter Resources and Costs: PV and EV are keystones of the approach. Most scheduling tools use resources and their costs to automatically calculate EV and PV. Assign resources to tasks in the schedule and enter resource rates. The rates do not have to be exact—approximations will do. Again, these points may seem obvious to experienced PMs, but in the field, they are often omitted.

Taking these steps will ensure good quality data for ES evaluation. To perform the calculations, there are a couple of alternatives.

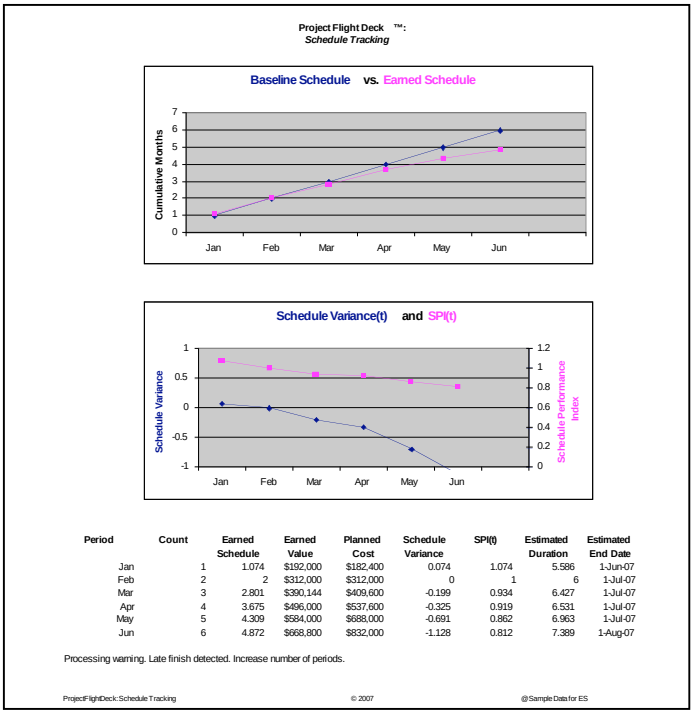
Semi-Automatic: Many scheduling tools provide a function that enables PMs to extract a file of time-phased data. The time-phased data can then be input into the spreadsheet accompanying this article for the ES calculations.[6] It can be found by going to http://www.pmforum.org/library/papers/Van_de_Velde.xls

For example, in MS Project (Project 98-2003), there is a Wizard called, "Analyze Timescaled Data in Excel".[7] To produce the Excel file, execute the Wizard for the Entire Project, set the date to the Actual Time, add the Planned Value (BCWS) and the Earned Value (BCWP) to the output list, specify the time periods and units (e.g., months), and produce the time-phased data file. The total PV and EV for each period can easily be copied from the time-phased data file into the spreadsheet for further calculation. Here is a completed spreadsheet.

Project Flight Deck ™
ES Calculator

	Period	Planned Value	Earned Value			Period Count	Earned Schedule	Schedule Variance	Schedule Performance Index	Estimated Duration	Estimated Completion Date
Enter values in bold:	**Jan**	**$182,400**	**$192,000**		Calculated Values:	1	1.074	0.074	1.074	5.586	1-Jun-07
	Feb	**$312,000**	**$312,000**			2	2	0.000	1.000	6.00	30-Jun-07
	Mar	**$409,600**	**$390,144**			3	2.801	-0.199	0.934	6.43	30-Jun-07
	Apr	**$537,600**	**$496,000**			4	3.675	-0.325	0.919	6.53	30-Jun-07
	May	**$688,000**	**$584,000**			5	4.309	-0.691	0.862	6.96	30-Jun-07
	Jun	**$832,000**	**$668,800**			6	4.872	-1.128	0.812	7.39	1-Aug-07

Fully Automatic: Commercial plug-ins for standard scheduling tools are available. The report below, for instance, is produced by a MS Project plug-in that extracts the required data from MS Project, calculates the ES values, analyzes the results, and dynamically creates an Excel file to hold the output.



Period	Count	Earned Schedule	Earned Value	Planned Cost	Schedule Variance	SPI(t)	Estimated Duration	Estimated End Date
Jan	1	1.074	$192,000	$182,400	0.074	1.074	5.586	1-Jun-07
Feb	2	2	$312,000	$312,000	0	1	6	1-Jul-07
Mar	3	2.801	$390,144	$409,600	-0.199	0.934	6.427	1-Jul-07
Apr	4	3.675	$496,000	$537,600	-0.325	0.919	6.531	1-Jul-07
May	5	4.309	$584,000	$688,000	-0.691	0.862	6.963	1-Jul-07
Jun	6	4.872	$668,800	$832,000	-1.128	0.812	7.389	1-Aug-07

Processing warning. Late finish detected. Increase number of periods.

ProjectFlightDeck: Schedule Tracking © 2007 @Sample Data for ES

Closing Comments

Earned Schedule expresses schedule performance not in terms of cost, but in terms of time—an intuitive approach. ES does not break down toward the end of a project. Projects finishing late show negative schedule variance and a performance index less than one.

Traditional EVM lacked the ability to predict end date. ES supports estimation of duration and, therefore, completion date. ES has recently been extended to measure schedule adherence, enhancing its predictive capability.[8] Additional refinements and extensions of the ES approach will undoubtedly continue, as it is new and fertile theoretical ground. Equally challenging is ES implementation in the field.

EVM adoption has grown slowly. Its traditional cost management focus has been an inhibitor, especially as time-drive (often, fixed price) projects have become the norm. Lipke's new approach will help remove this barrier.

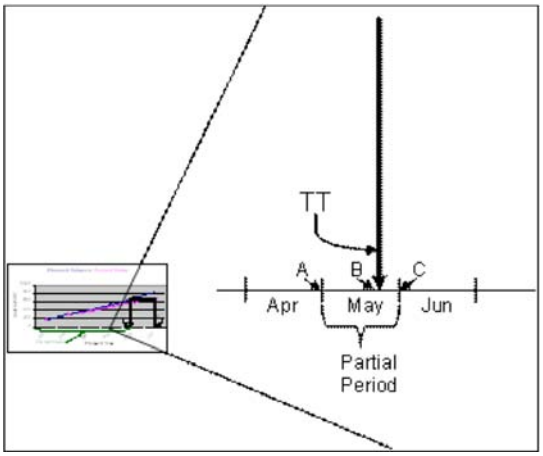
The increased professionalism evidenced by the growth in project management certifications will also help. Along with professionalism come both an expectation of disciplined practice and the use of more objective measures of project performance. The days of flying-by-the-seat-of-our-pants are over. Quantitative analysis does not replace experience and intuition, but it is a necessary supplement and support to them.

Time is up. Higher expectations of Project Managers combined with increased emphasis on time-driven projects signal a turning point in project management practice. Now is the time to adopt techniques like Earned Schedule.

Appendix

The calculation of the fractional amount of earned schedule is briefly described in the text. A more detailed explanation follows.

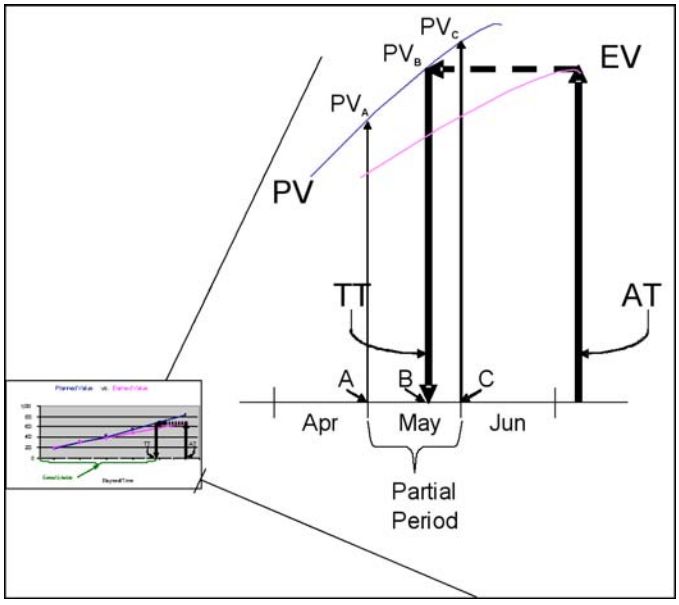
The chart below expands a portion of the diagram used earlier to describe Lipke's approach.



The basic idea is to express the value of the partial period as a fraction: B-A / C-A. The denominator takes the cumulative value at C and subtracts from it the cumulative value at A, leaving the value of the partial period as remainder. The numerator takes the cumulative value at B and subtracts from it the cumulative value at A, leaving the value of the earned part of the partial period.

There is a problem: the Target Time, TT, is not known. Scheduling tools do not generate or track it. There is no simple calculation to derive it. Lipke states that interpolation is the answer. By interpolation, he means that the value of the fractional amount will be approximated by using known values from the planned value curve.

Another diagram helps explain the approximation.



Even though we do not know the key time, TT, we know its corresponding Planned Value, namely PV_B. PV_B is equal to the EV at AT. We also know the PV at A and at C, the start and end dates of the partial period. So, we can substitute the known PVs in the fraction stated previously, giving us this formula:

$$PV_B - PV_A / PV_C - PV_A.$$

Because the $PV_B = EV_{AT}$, the formula is generally expressed as follows:

$$EV_{AT} - PV_A / PV_C - PV_A.$$

In sum, because the time value of TT cannot be directly calculated, the value of the partial period is approximated by using corresponding, known values from the PV curve.

End Notes

[1] Christensen, D.S., Antolini, R.C., McKinney, J.W., *A Review of Estimate at Completion Research*, Journal of Cost Analysis and Management, Spring, 1995, pp. 41-65. See also Christensen, D.S., Templin, C., *EAC Evaluation Methods: Do They Still Work?*, Acquisition Review Quarterly, Spring, 2002, pp. 105-116.

[2] Vandevoorde, S. , Vanhoucke, M., *A Comparison of Different Project Duration Forecasting Methods Using Earned Value Metrics*, International Journal of Project Management, 2006, pp. 289-302. See also Corovic, R., *Why EVM Is Not Good for Schedule Performance Analyses (and how it could be…)*, The Measurable News, Winter, 2006-2007.

[3] Lipke, W., *Schedule Is Different*, The Measurable News, Spring, 2003, pp. 1-10. See also Henderson, K., *Earned Schedule in Action*, The Measurable News, Spring, 2005, pp. 1-10; Henderson, K., *Further Developments in Earned Schedule*, The Measurable News, Spring, 2004; Henderson, K., *Earned Schedule: A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of Real Project Data*, The Measurable News, Summer, 2003, pp. 1-10. The Web Site www.earnedschedule.com is an excellent source of material on this topic. The references in this article can be found on or through this Web Site.

[4]Lipke, W., Haupt, E., Robinson, S., *Earned Schedule Workshop*, PMI - CPM Conference, May 2004, see pp. 20-21 in particular.

[5] For a survey of Earned Schedule calculations, see Haupt, E., *Earned Schedule—Emerging Practice*, Training, 2006, pp. 24-39.

[6] For updated versions of the spreadsheet, see www.projectflightdeck.com. Lipke also provides spreadsheets for performing ES calculations. See the "es calculator" tab in www.earnedschedule.com.

[7] In MS Project 2007, the "Analyze Timescaled Data in Excel" Wizard is no longer available; so, the procedure is different. To generate the required data, use the Report option, select the Earned Value report, remove all fields except for Earned Value and Planned Value, create the report, and edit the Excel table to display the values for the time period you desire (months, weeks, or days). Copy the values from the table into the spreadsheet for the ES calculations.

[8] Lipke, W., *Earned Schedule Leads to Improved Forecasting*, Proceedings of the PROMAC Conference, September, 2006.

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Robert Van De Velde, PhD, PMP is an experienced project manager with a significant track record completing projects on time and on budget. He has delivered award-winning projects in financial services, natural resources, and telecommunications. His articles have appeared in the *Journal of Systems Management* and *People and Information*. Rob holds a Ph.D. and has earned certifications in project management and MS Project. His current research interests include techniques for managing time-driven projects, automation of project status analysis and reporting, and the use of advanced features in MS Project. Rob received his Ph.D. from the University of Toronto. He holds a B.Sc. from the University of Manitoba. He resides in Toronto, Canada. Rob operates a commercial Web Site that features plug-ins for MS Project. See www.projectflightdeck.com for more information. You can reach Rob via e-mail at info@projectflightdeck.com.