EVM.04

Applying Earned Schedule Analysis to EVM data for Estimating Completion Date

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For more than 30 years earned value management has been providing valuable insight into project cost and schedule status during project execution. A study of more than 700 completed major programs over three decades has shown that earned value provides insight into the project health when as little as 15 percent of the work is complete. 1 However, while traditional earned value management did an excellent job of estimating the final cost of the project, it failed to do the same for estimating the completion date. Recently, new work in the application of earned value management principles has created novel approaches to obtain schedule information from the application of earned value management, and have resulted in means to predict the project completion date.

First, a little background: Earned value management is based on three metrics about the project: planned value, earned value, and actual cost.

The planned value is the value of tasks to be completed. While this sounds like simply the project budget, it is the sum of each task's time phased budget. This is created by associating applicable budget to each detailed element of work and knowing when the work is scheduled. Thus each piece of work has two attributes: what is its value (allocated budget) and when is it to be completed (allocated time, or schedule). Using a WBS facilitates detail planning and budgeting and summarizing it at the project level.

When this is done the result can be plotted as planned value versus time. (See figure 1). While this looks like just a typical project spend plan its basis is quite different. Often a spend plan is just created from budgeting labor, material, and other costs over the lifetime of the project at a summary level. When implementing earned value management the chart is derived from determining the budget for each element of work and when it is scheduled to be underway or completed.

Earned value is the result of completed tasks. When tasks are completed they contribute to the project's earned value. At the beginning of the project the earned value is zero. As each task is completed it adds to the project's total earned value.

The amount of each task's contribution is equal to its planned value that was defined during the planning process. At the end of the project the earned value equals the planned value since all the scheduled work is done. Note that I have not introduced any discussion of actual cost or funds spent. A key element of earned value management is that work has value equal to its budget, not what was spent completing the work.

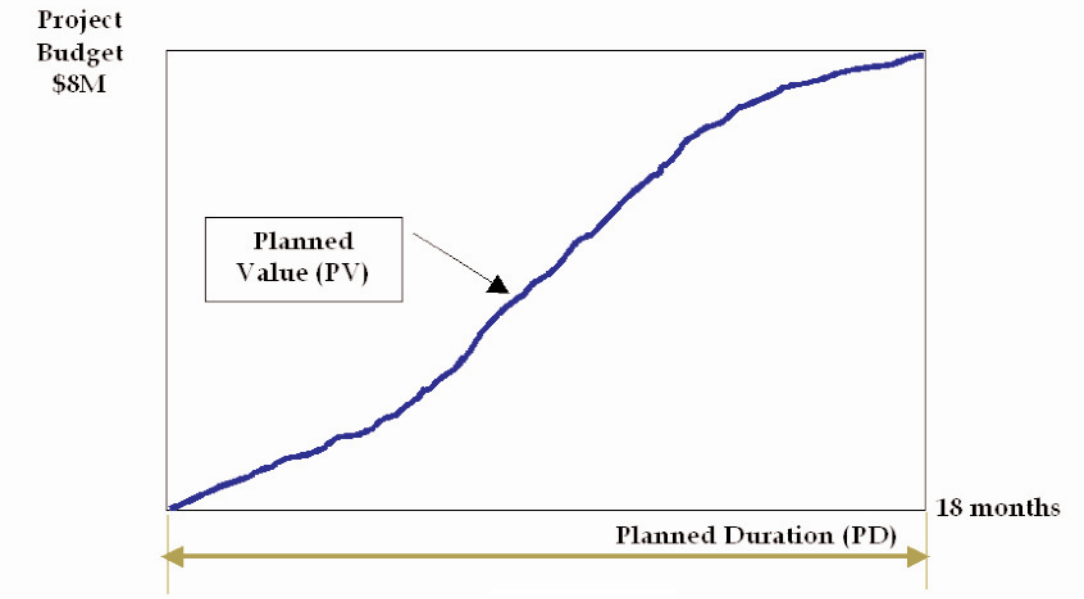

Figure 1—Planned Value Verses Time

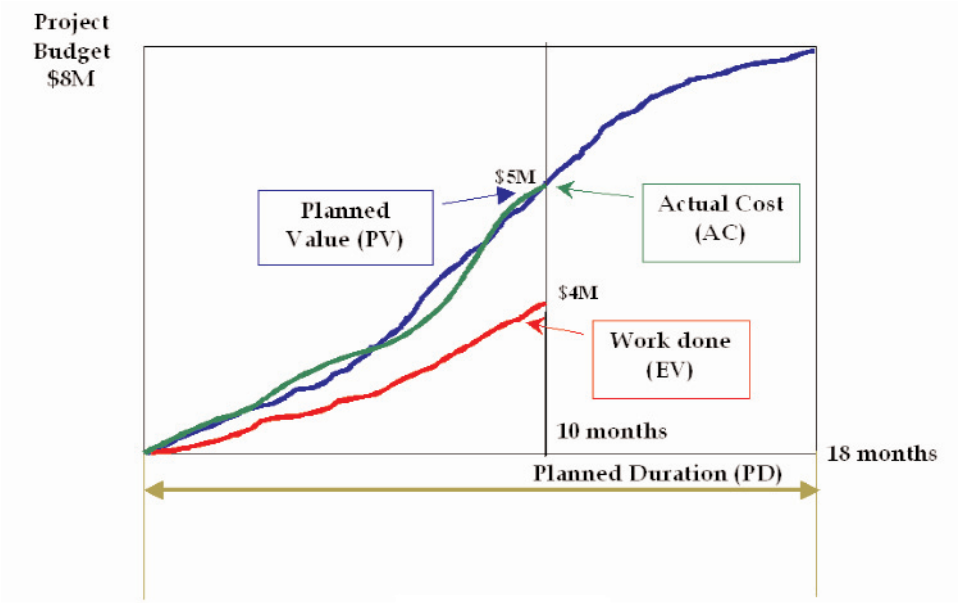

Figure 2

The actual cost is exactly what its name suggests. It is the cost of completing each task, often as reported by project financial reports using a WBS.

At any point during the execution of a project we have three earned value management parameters to evaluate: planned value, earned value, and actual cost. (See figure 2:) Comparing the planned value to the earned value at a point in time provides schedule information. For example, if, at a point in time our planned value is $5 million but our earned value is only $4 million then clearly there is work valued at $1 million that has not been completed.

If, at this point in time our actual cost is $5 million then we have a cost over run as well. Why? While we planned to complete $5 million (planned value) of work at a cost $5M (actual cost), we only really completed $4 million of work (earned value). So we've spent $5 million to get $4 million of work done. Note that without earned value management, we would compare our planned expenditure of $5 million to our actual costs of $5 million and reached the erroneous and dangerous conclusion that we are right on budget!

Earned value management can give us valuable cost and time (schedule) efficiency calculations. The cost performance index (commonly called the CPI) is simply the earned value divided by the actual cost. So if the result is greater than 1 we have more value in our completed work than we have spent. If it is less than 1 then the work is costing more than was planned. This index is remarkably stable once a project is more than 15-20 percent complete.

Since the costs of resources and the work scope are known, the CPI is a good predictor of the final cost of the project. One simple formula for estimating the final cost is to divide the project budget by the CPI. (Algebraically this simple formula takes the cost incurred to date and adds an estimate of the cost to complete the remaining work.) At the end of the project one can calculate a final project CPI for historical records. Since all the work is complete the earned value now equals the planned value, and all the actual costs are known. So the final CPI is simply the earned value (or planned value, they are the same value at project end) divided by the final cost to complete the project.

The schedule performance index (SPI) shows how well we are spending time. It compares how much work should be done to what has been done. It is computed by dividing the earned value by the planned value. Like the CPI, if the result is greater than 1 we have completed more work than we planned. If it is less than 1 then the work is behind schedule. There are no accepted formulas to estimate the final completion date as there are for final completion cost. This reason has to do with the behavior of SPI near the end of the project.

Recall that at the end of the project the earned value must equal the planned value. Thus the SPI *must be 1.0 at the end of the project* regardless of how early or late the project completes. Thus the SPI is an unreliable parameter to compute an estimated completion date. At some point around 2/3 into the project the SPI begins to become meaningless. This is one reason earned value management has been considered stronger in cost management than schedule management. But that is about to change.

Earned schedule is a new concept developed by Walt Lipke and informally validated by Kym Henderson and formally researched by S. Vandevoorde and M. Vanhoucke [2, 3, 4]. Rather than just looking at schedule performance using the value of work, earned schedule also looks at when the work was to be completed.

This requires the definition of a few more terms. Earned schedule (ES) is the point in time when the current earned value was to be *accomplished*. (Note that I've used *earned schedule* both as a new term and a title for this new concept in earned value management.) In other words, at what point in time was the project planned value supposed to equal the current earned value? To do this, we find the point on the planned value line that equals the current Earned Value and note when it was to occur. This date is the earned schedule. The other new parameter is simply the actual time (AT) that has expired since the time the project started.

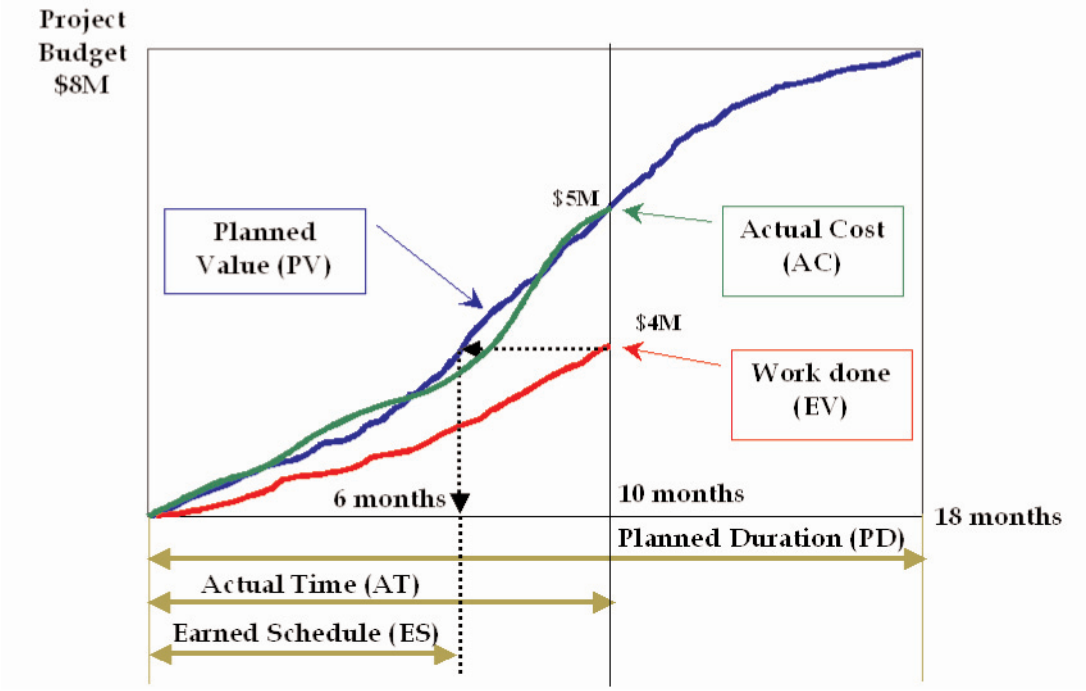

Figure 3—Schedule Performance Index

We can compute an SPI using the earned schedule and actual time parameters. This is simply the earned schedule divided by the actual time. Like our traditional SPI, a value greater than 1 shows an ahead of schedule condition. For example, suppose that our earned schedule is six months and the actual time is ten months. The SPI is 0.6 (6/10). We completed six months of work in 10 months, so the SPI is less than 1.

Since both the traditional and earned schedule based SPIs can be used there is a need to differentiate the two SPI terms. Two evolving nomenclatures are SPI (t) and SPI ($), or SPIt and SPI$, for new Earned Schedule based SPI and the traditional SPI, respectively.

We can compare these two types of SPI at month 10 and compare the results. Assume we have an $8 million project and we are at month 10 in its 18-month schedule. Further assume earned value management values of planned value and earned value might be $5 million and $4 million at month 10. (See figure 3). The SPI ($) is simply 4/5 or 0.8. From a look at the planned value curve we see, however, that $4 million was the planned value of work for month 6, not month 10. So we are clearly behind schedule. The SPI(t) at this time is 6/10 or 0.6. We have completed work planned for month six, but unfortunately it's month 10!

Clearly we get different results for the two SPIs; hence, the need for unique terminology for SPI.

Let's assume our project completes in month 25 and recalculate our two SPIs. Since the project is complete the earned value must equal the planned value. So SPI($) is $8M/$8M or 1.0. We know, however, that originally we planned to have all the work done in month 18. So the earned schedule is 18 while the actual time is 25. SPI(t) is 18/25 or 0.72.

The important observation is that SPI(t) remained a good indicator of project status while the SPI($) ended up at 1.0 even though the project completed seven months late! During the time span between the middle of the project and the end SPI($) became less and less accurate.

Which brings us to the remarkable ability of SPI(t) to predict our project completion date. This is something that SPI($) cannot do since it is unreliable toward the end of the project.

One more new term to earned value management is planned duration (PD) which is simply the original duration of the project, in our case PD=18. The estimated final duration is simply the planned duration divided by the SPI(t). At month 10 of our project our SPI(t) was 0.6. So at that time we would have estimated the final duration as 18/0.6 or 30 months. (Clearly we did recover some schedule since we finished sooner.) If we were at month 18 with a SPI(t) of say 0.80 we would have computed an estimated duration of 22.5 months. However at this late point in the project our SPI($) would be useless and approaching 1.0 since the earned value is getting close to the planned value.

Use of earned schedule promises to improve earned value management's ability to accurately represent and forecast schedule information on a par with its traditional ability to represent and forecast cost information.

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