Earned Value Management (EVM) Technique: Has it Outlived Its Usefulness?

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Abstract—**In project management, project performance during execution is often measured by comparing the amount of work planned with what was actually performed and what was actually spent to determine if cost and schedule performances are as planned. Because Earned Value Management (EVM) has much longer history than Earned Schedule (ES), literature on the latter is much fewer. Nevertheless, interest in ES has increased in recent times. Therefore, the purpose of this study is to examine the body of literature primarily, on EVM and ES techniques in order to determine whether EVM has outlived its usefulness; determine the more appropriate technique for measuring cost and duration performance; and provide recommendations.**

Guided by extensive literature review, the author used quantitative data and graphical illustrations to demonstrate practical applications of cost and schedule performance measurement objectives. It was revealed that EVM has not outlived its usefulness. However, it was confirmed that EVM technique is more appropriate for measuring cost performance on projects, while ES is more appropriate in measuring duration performance. Given these observations, the author as are others in the published literature recommend applying both techniques.

***Keywords*: Earned value management; earned schedule; planned value; earned value, actual cost; actual duration; performance measurement;**

INTRODUCTION

The sub-title of this paper asks a very pointed question: Earned Value Management (EVM) technique: has it outlived its usefulness? The Project Management Institute (PMI, 2013) defines EVM as a methodology that combines scope, schedule, and resource measurements to assess project performance and progress. For Schwalbe (2014), Earned Value Management (EVM) is a project performance measurement technique that integrates scope, time, and cost data. And for Oosthuizen and Venter (2011, eds.), EVM is a particular method for monitoring the progress and performance of projects. From Bruchey's (2012) view, the EVM concept is a project management tool that integrates project scope with cost, schedule, and performance elements for optimum project planning and control. All of these authors/sources have one thing is common about their perspectives on EVM. They all assert that EVM integrates scope, time, and cost in the measurement of project performance. Ironically, scope, time, and cost are collectively the so called, 'triple constraint' in project management. It is postulated that given a cost performance baseline, project managers and their teams can determine how well the project is meeting scope, time, and cost goals. They can accomplish this by entering actual information and then comparing it to the baseline. It is further observed that by so doing, EVM can enable project managers to not only forecast future trends in performance, but also identify potential problems before they occur (Oosthuizen and Venter, 2011, eds.).

The author of this study has some reservations about some of the above assertions. These concerns raise some questions in the mind of the author. For example, Is the traditional EVM an adequate technique to monitor, measure, and evaluate schedule performance on long duration projects? Can EVM technique accurately monitor, control, and evaluate specifications, requirements, quality, and technical performance (scope) on a project? Can EVM technique properly forecast project completion time on a long-duration project? These are the concerns that motivated this study. The author does not believe that EVM is an adequate technique to accurately monitor, measure, and evaluate schedule progress and duration performance on projects. Given the very elements of EVM, the author believes that EVM technique is more suitable to monitor, measure, and evaluate cost performance, rather than time and scope performance. Therefore, the purpose of this study is to examine the body of literature primarily, on EVM and Earned Schedule Management (ESM, also simply referred to as earned schedule or ES) techniques in order to identify the common denominators between these techniques; and assess different techniques for monitoring and measuring progress and performance in terms of project time and cost. From now on, Earned Schedule Management will be referred to as Earned Schedule (i.e., ES).

In light of the above background, this study will examine three bodies of literature: one relating to EVM, a second relating to Earned Schedule (ES) technique, and a third relating to project scope. Project scope will not be discussed in detail in this study. Project scope will not be investigated as a performance measurement tool or technique. It is referenced in this study because a project success or failure is usually measured against these three performance parameters or criteria. As such, project scope will only be discussed briefly. The primary considerations in this study are on EVM and ES.

There is a considerable body of literature devoted to EVM. For example, Anbari (2003); Singletary (1996); PMI (2013); Larson and Gray (2014); Henderson (2003); and Gido and Clements (2015) just to name a few, have written extensively on EVM. However, the literature on ES as a performance measurement technique to monitor, measure, and evaluate project progress and performance is rather thin. In fact, most textbooks and articles on project management do not discuss the subject. This study seeks to extend the discourse in this topic area of project management. In order to achieve this overall aim, the study will attempt to answer the following four questions:

1. What is the triple constraint?
2. Has EVM outlived its usefulness?
3. Does EVM accurately monitor, measure, and evaluate project progress in terms of time and cost performance?
4. Is there an alternative, better technique to monitor, measure, and evaluate project performance in terms of time?

In order to answer the above questions, specifically, within the context of EVM and ES, the objectives of this research study are to:

1. Identify and briefly discuss the elements of the triple constraint.
2. Explore EVM and ES methods in practice.
3. Evaluate the two techniques in order to determine which one is more appropriate for forecasting cost performance and project time performance.
4. Make recommendations to inform project management practice.

It is against this backdrop that this study attempts to provide the logic for the relationship among the elements of the triple constraint and then shifts to and focuses on EVM and ES in the detailed narrative of the study. After a brief review of the triple constraint, the paper outlines the elements that are considered in each of the two main (i.e., EVM and ES) concepts and the roles they play in project management. The paper also discusses the practical implications of the roles these methods play in project management and the consequences of not using an appropriate technique for a given purpose. As Lipke (2007) observed, an objective of project management is to have the capability to reliably predict cost and schedule outcomes. Applying Statistical Methods to Project Management, he noted that the application of statistical methods to cost and schedule indicators from EVM and ES is a well-founded means for providing the project management objective. In order to achieve the stated objectives and answer the formulated research questions, the author will seek out literature from a number of sources including, books, journals, conference proceedings, reports, and theses both print and electronic sources.

Having given context and background to the study, the rest of the paper will be structured as follows: section 2 (literature review), section 3 (analysis and discussion), and section 4 (conclusions and recommendations).

LITERATURE REVIEW

This section is intended to set this study within its wider context and to show that the study supplements the work that has already been done on Earned Value Management (EVM) and Earned Schedule (ES). In order to set the scene for the rest of this section, the author briefly reviews the triple constraint. Thereafter, a critical review of the two primary concepts of this study is conducted.

The Triple Constraint: Project Management Trade-offs

Project managers often compare actual results against baselines. Three of these baselines are the scope baseline, schedule baseline, and cost baseline. The triple constraint on a project consists of scope, time, and cost. Schwalbe (2014) expressed the importance of the triple constraint thus: "Every project is constrained in different ways, often by its scope, time, and cost goals." She emphasized that to create a successful project a project manager must consider scope, time, and cost and balance these three often-competing goals. Shifts in the relative importance of these performance parameters are major causes of project trade-offs. Knowing these three major constraints on a project would enable the project manager to establish priorities. Larson and Gray (2014) also articulated that priority information is essential to the planning process, where adjustments can be made in the scope, schedule, and budget allocation. Every project must answer three fundamental questions: what, when, and how much. Sometimes, these questions are referred to as the project objectives. In these questions, the 'what', asks scope (i.e., performance, quality, specification, or the deliverables) question; the 'when', asks time (i.e., schedule) question; and the 'how much' asks cost (i.e., budget) question. Given these three aspects of concerns, an example of project objective would be: to acquire an additional technical certificate by June 29th 2016 at a cost of no more than $1,000.00. For Hartley (2009), there are four prime constraints (or variables) that drive the project – time, cost, specification, and resources. Instead of the usual triangle, he depicted his views about

project constraints in a rectangle. Nevertheless, this study will stick with the triangle version of the constraints.

In most projects, the scope, time, and cost dimensions serve as the key performance indicators (KPIs) to measure progress and evaluate success (i.e., whether the project goals are achieved). The triple constraint refers to the relationship among the three dimensions. These three variables placed on the three corners (or sides) of the triangle form an interdependent set. This means that if any one of them changes, at least one other variable must also change to restore balance to the project.

Project Scope

The PMBOK® Guide (5th ed. 2013) addresses different elements related to scope. It defines scope as the sum of the products, services, and results to be provided as a project; defines project scope as the work performed to deliver a product, service, or result with the specific features and functions; defines statement of work (SOW) as a narrative description of products, services, or results to be delivered by the project; and defines project scope statement as the description of the project scope, major deliverables, assumptions, and constraints. According to Kerzner (2013), the scope statement addresses seven questions: who, what, when, why, where, how, and how many. One of the most vexing issues for a project manager is scope creep. This is the insidious tendency for a project to grow in scope as it unfolds. As has been pointed out earlier, some authors refer to the scope dimension as the performance dimension. Brown and Hyer (2010) observed that performance (i.e., scope) is the most broadly defined of the triple constraint elements and may include scope, quality, extent to which specifications are met, ability of the product to perform required functions, and other factors.

To create a successful project, Schwalbe (2014) stresses that a project manager must consider the three dimensions of the project and balance these three often-competing goals. Consideing the scope dimension, she asks three crucial questions: what work will be done as part of the project? What unique product, service, or result does the customer or sponsor expect from the product? How will the scope be verified? In a sense, scope is a statement that defines the boundaries of the project. It defines not only what will be done but also what will not be done. So, we can see the scope document as the foundation for all the project work to follow. Therefore, whatever is not inscope, is out of scope and should be treated as such. During project execution, any request for a change in scope will require performing a formal change control process. In the practice standard for earned value management (PMI, 2011), it is stated that PMI uses the term project scope to mean the work that must be performed to deliver a product, service, or result with the specified features and functions. It is further stated that EVM can play a crucial role in answering management questions that are critical to the success of every project. In this respect, the standard poses the following questons:

1. Are we delivering more or less work than planned?
2. When is the project likely to be completed?
3. Are we currently over or under budget?
4. When is the remaining work likely to start?
5. What is the entire project likely to cost?
6. How much will we be over or under budget at the end of the project?
7. What is driving the significant cost and/or schedule variances?

These questions captured the spirit of the questions posed by Kathy Schwalbe as highlighted earlier.

Project Schedule

Similarly, Schwalbe (2014) poses four questions about the time dimension: How long should it take to complete the project? What is the project's schedule? How will the team track actual schedule performance? Who can approve changes to the schedule? She states that managing the triple constraint involves making trade-offs between scope, time, and cost goals for a project. In addition, one can also ask questions such as: when is the project expected to start? Under what conditions will time extensions be considered? Are there any benefits in completing the project ahead of schedule? On projects, the client specifies a time frame or specific date when the project must be completed. To an extent, cost and time on projects are inversely related to each other. For example, in order to compress a project's completion date, more resources can be assigned to the project (i.e., fast tracking). However, reduction in time by utilizing more resources, will cause increases in cost. In this respect, a trade-off between time and cost is made. This decision is dictated by the priority established earlier. Time is an interesting resource that cannot be inventoried. It is consumed whether it is used or not. This perspective is different from the way the general public views time. The general public views time as a social construction, perceived differently by different people. In this respect, time is defined as a physical entity, measurable by time clocks.

Furthermore, the general public sees time as cyclical, linear, or alternating back and forth. In projects, however, time is seen differently: time is temporary; must be monitored, controlled, and measured as has been observed earlier. The amount of time available will determine the project's schedule of work. Some projects can be completed ahead of time/schedule, some on time/schedule, and others behind time/schedule. These are the only three duration-related possibilities in project management.

Project Cost

The cost of a project can be thought of as the budget that has been established for the project. This is the estimated and approved cost to fund the required work to the required standard during the required time allowed. So cost is often expressed in monetary terms. According to Andersen (2008), the project Costs represent every sacrifice made for the sake of the project, again expressed in nonetary terms. Andersen further states that costs represent spending on human resources (employees from the base organization, hired consultants); procurement of equipment and material, travel, meetings; IT equipment and use; office accommodation; and so forth. By studying the costs, the organization can estimate the extent of the sacrifice required to sustain the project. As on time, there can be three perspectives about costs on projects: some projects are under-funded, some are excessively funded (a rarity), while others are adequately financed (another rarity, particularly at the initial stage). These situations can be addressed to some extent if the following questions are considered: what should it cost to complete the project? What is the project's budget? How will costs be tracked? How was the estimate determined? Has contingent funding been provided? What are the draw down (access) procedures for spending the budget? The cost dimension can be broken down to managable components containing direct, indirect, and overhead costs.

Among the three dimensions of the triple constraint discussed above, only time and cost performances are the variables that the EVM and ES techniques considered in this study will address. Figure 1 is an example of the triple constraint.

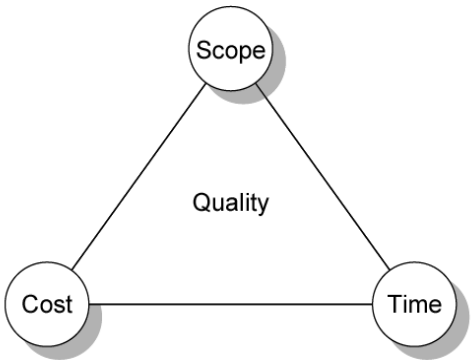

Figure 1: The Triple Constraint

Next, the two key variables in this study are critically reviewed. These are the Earned value Management and the Earned schedule variables.

Earned Value Management (EVM)

Many have attempted to define earned value management (EVM). For example, Pajares and Lopez-Paredes (2009) define EVM as simply, a management technique for project performance monitoring. They proposed that EVM integrates scope, cost, and schedule control under the same framework and that it provides performance variances and indexes which allow managers to detect over-costs and delays. For Kerzner (2013), EVM is a systematic process that uses earned value as the primary tool for integrating cost, schedule, technical performance management, and risk management. Meredith and Mantel (2012) on the other hand, define Earned Value (EV) as an approach for monitoring project progress that relies on the budgeted cost of activities completed to ascribe value. They describe EV as a way of measuring overall performance by using an aggregate performance measure. In the fourth edition of the *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), PMI provided a different connotation.* In that standard, PMI (2008) defined EV as the value of work performed expressed in terms of the approved budget assigned to that work for a schedule activity or work breakdown structure (WBS) component. However, in the PMBOK® Guide, Fifth ed. 2013), PMI defines EV simply as "The measure of work performed expressed in terms of the budget authorized for the work", p. 538. With a different articulation, Maylor (2010) expresses that for complex projects where warning of problems and an ability to predict final costs and times at completion is required, the use of the concept of earned value can be most useful. He maintains that EV brings together time and cost performance elements into a monetary quantity – a unit that is easily understandable, p.297. Similarly, Hartley (2009) defines EV as a measure of performance (progress) in terms of schedule and budget metrics and implications. Earned value management on the other hand, is considered by many to be one of the most effective performance measurement and feedback tools for managing projects (PMI, 2011).

Furthermore, in the Fourth edition of the PMBOK® Guide, PMI defines EVM as a management methodology for integrating scope, schedule, and resources, and for objectively measuring project performance and progress. It adds that performance is measured by determining the budgeted cost of work performed and comparing it to the actual cost of work performed, 2008, p.433. Similar to EV, in the Fifth edition of the PMBOK® Guide, PMI defines EVM simply as "A methodology that combines scope, schedule, and resource measurements to assess project performance and progress," 2013, p. 538. PMI's definition of EVM echoes that of Pajares and Lopez-Paredes cited earlier. In agreement with their definitions, it means EVM can be used to monitor and measure parts of projects or the overall project (i.e.,

performance and progress). One thing that all the various definitions of EVM have in common is the integration and measurement of performance and progress on scope, time, and cost.

In project management, project performance is measured or evaluated by comparing the amount of work planned with what was actually performed and what was actually spent to determine if cost and schedule performance are as planned. Most project management practitioners also view scope, time, and cost as the three primary criteria or objectives for assessing a project's success or failure. The definitions in this section and the others provided earlier in the introductory section attest to the popularity of EVM techniques as a performance measurement tool utilized in project management practice. But, is EVM adequate in accurately measuring scope, time, and cost performance and progress? Is EVM the appropriate tool for forecasting project completion duration? Or is there a better alternative tool for forecasting project completion duration? These questions will be addressed later in the discussion and analysis section of this study.

Despite the popularity, wide acceptance, and utilization of EVM, Lipke made cautionary remarks about EVM. He postulated that EVM methods for forecasting project duration have been taught in training courses and used by project managers for four decades [It's more than four decades now]. He cautioned that these EVM methods are generally considered to be accepted practice, yet they have not been well studied and researched as to their predictive capability. In an attempt to provide convincing evidence about an alternative method (i.e., the ES), Lipke used real project data to examine and compare the duration forecasts from four EVM methods to the ES prediction technique. From the results, he was convinced about the predictive superiority of ES as a more accurate predictor for project duration. In a separate study, Henderson (2003) carried out a study to test the claim made by Lipke. Henderson's results confirmed Lipke's and came to the conclusion that ES is a better method for measuring, monitoring, and controlling project duration performance.

As the above observations show, EVM has as many perspectives as are authors writing about it or discussing the concept. For Sparrow ((2002), EVM is a project management tool that enables managers to identify and control problems before they become irrecoverable. Comparing EVM to traditional accounting performance measures that simply compare planned expenditure with how much has been spent, Sparrow says that EVM goes a step further. He emphasizes that EVM provides an objective indication of actual accomplishment. Like most other EVM devotees, Sparrow maintains that EV metric can be used to assess both cost and schedule performance. This sentiment is shared by many others including Kendrick (2006) who observes that EVM is about a structured approach to governing the deployment of resources to achieve measurable results on a defined schedule and within planned budget estimates. These advocates see EVM as a project management methodology capable of providing accurate forecasts of project performance problems (both cost and schedule). This notion is a product of the EVM origin with the United States Department of Defense in the 1960s as part of its Cost/Schedule Control Systems Criteria (C/SCSC). By this mandate, contractors were initially required to adopt this system when reporting on schedule and cost performance. This notion influences the various definitions of EVM given above. Habits die hard and change requires a paradigm shift.

Earned Schedule Management (ESM or ES)

Similarly, various definitions have been advanced for ESM or ES. Similar to the simple definition provided for EVM, Pajares and Lopez-Paredes (2009) also provided a simple definition for ES. They define ES simply as the date when the current earned value should have been achieved. Lipke (2007), the father of Earned Schedule (ES) described ES as a breakthrough analytical technique that resolves the EVM dilemma. He stated that ES is derived from and is an extension to EVM. Similar to Pajares and Lopez-Paredes (2009), Stratton (2007) defines ES as the point in time when the current value was to be accomplished. Henderson and Lipke (2004) expressed ES as the cumulative earned value (EV) in time units (t) as established by the cumulative BCWP on the BCWS curve. BCWP (budgeted cost work performed) is the former term for EV and BCWS (budgeted cost of work scheduled) is the former term for Planned Value (PV). Henderson in his attempt to validate Lipke's idea about EVM conducted a separate study in order to validate the superiority of ES over EVM in forecasting schedule performance. In that study, Henderson (2003) stated that ES is claimed to be analogous to Earned Value except that a time or duration based measure of schedule is used instead of cost for measuring schedule performance. In Henderson's view, ES can be used to calculate measures intended to be analogous to EVMs cost based counterparts. In the glossary section of the Practice Standard for Earned Value Management (PMI, 2011), 2nd ed., PMI provided two definitions that are pertinent to this section's review: Earned Schedule Method and Earned Schedule Measure. In the glossary section of this practice standard, PMI offered the following information on Earned Schedule Measure (ES):

The time duration where EV equals PV, It measures the scheduled work accomplished, expressed in the time based unit of measure being utilized (e.g., week, month). ES can be reported either cumulative to date or for a specified reporting period. ES (cumulative) is equal to C plus I where C is the number of PMB time periods for which EV is equal to or exceeds PV. When EV exceeds PVc, I is the fractional amount of ES for the subsequent incremental PV period. I is equal to (EV – PVc)/(PVc+1 – PVc). P.146.

In addition, in the glossary section of the Practice Standard for Earned Value Management (PMI, 2011), 2nd ed., PMI also offered the following information on Earned Schedule Method*: A method for extracting time-based schedule information from EVM data*, p.146. In the practice standard, PMI states that each practice standard is intended to be more prescriptive than the PMBOK® Guide. In fact, the PMBOK® Guide published as of 2013 (the latest being the 5th edition) did not discuss Earned Schedule Management (ES) as it did Earned Value Management (EVM). However, ES is discussed in the Practice Standard for Earned Value Management, cited above. Nevertheless, this practice standard is consistent with the PMBOK® Guide as it is developed as a supplement to the PMBOK® Guide. PMI (2011) asserts that a practice standard is a document that describes established norms, methods, processes, and practice.

Analysis and Discussion

Earned Value Management integrates scope, schedule, and cost in a very intriguing way. Lipke (2003) comments that EVM measures schedule performance not in units of time, but rather in costs, i.e. dollars. His work also led him to discover another flaw of EVM. He observes that at the completion of a project which is behind schedule, schedule variance is equal to zero, and the Schedule Performance Index (SPI) equals unity. In this instance, it was known that the project completed late (SPI was supposed to be less than 1), yet the SPI indicator shows the project has perfect schedule performance [i.e., EV/PV = 1].

In his efforts to solve the long-standing dilemma of the EVM schedule indicators providing false information for late performing projects, Lipke introduced a viable solution to the problem. This solution was coined as Earned Schedule (ES) which he claims provides the ability to predict project completion dates. He states that ES serves as the bridge for performing meaningful schedule analysis from the EVM data. In other words, ES is the link between EVM and schedule analysis. Because the ES metrics use time based measures, he continues, they augment the traditional EVM and integrated schedule analysis. He emphasizes that ES can be used for detailed schedule analysis and that it has the potential to improve both cost and schedule prediction. Here again, caution should be taken to avoid the type of mistakes EVM makes, using the wrong units to measure a different variable. Schedule should be reported in time units and costs should be measured in monetary units.

Has EVM outlived its usefulness?

Considering the flaws with EVM in predicting project performance with respect to schedule, one might be inclined to think that EVM has lost its appeal and usefulness. Far from that, EVM has its devotees who are very passionate about the contributions of EVM to their project management outcome. EVM has its place in project management. Recently, there was an article in the PM Network entitled, "EVM: Still Proving Its Value." In that article, Burba (2015) stated: "The pace of change may be accelerating, but project leaders can't afford to leave earned value management behind." Making the case for the value of EVM, it was observed that thinking of EVM as a holdover system from an earlier age ignores the many perspectives it can bring to an organization. In that same article, Victor Tran, observed that "Done correctly, EVM also gives higher-ups better insight to the progress of the organization's projects". "If you don't do EVM and you just do status reports, you won't know the reasons for overruns", he emphasizes. In reality, EVM has not lost its appeal or usefulness. It is still a widely accepted method to evaluate project performance. This sentiment is shared by numerous studies. Anbari (2003) research shares this view. In his study, he articulated that EVM method helps managers in making evidence-based decisions about project scope, resources, and cost; and that as a result, it supports effective project cost control and oversight.

Furthermore, by integrating the three critical elements of scope, cost, and time, EVM can provide a clearer picture of the project performance in terms of cost status. EVM practitioners use EVM technique to evaluate the status of project cost and to forecast the project's cost at completion. Since EVM uses monetary units to report cost movements, it is a better technique for monitoring, evaluating, and forecasting cost-related dynamism on the project. Similarly, in a research funded with research grant from the Project Management Institute (PMI) and PMI's College of Performance Management (CPM), Song (2015) undertook a research on Earn Value Management (EVM). Song's research resulted among others, in the following key findings:

1. VM has spread worldwide, and is particularly popular in the Middle East, South Asia, Canada, and Europe.
2. VM use goes beyond the traditional defense/military and government sectors.
3. VM practice varies greatly with the highly diversified user profile.
4. VM's contributions and cost-effectiveness are widely recognized, regardless of industry sector, motivation, country, or other variables.

In another study, West (2001) finds that EVM enables management to effectively and efficiently integrate the work scope of a project or program with the schedule and cost elements for optimum program planning and cost management. She argues against past practices whereby management placed undue emphasis on technical performance as the main metric for performance evaluation. Weekly earned

value enables the early mitigation of cost, schedule, and technical risk, she adds.

Earned Value Management (EVM) Methods in Practice

Before reflecting on the practical applications of EVM, a brief description of the measures used in its calculations is in order. EVM uses the following key measures to assess project performance. Lipke (2013) as well as others provide the following descriptions:

- Planned value (**PV**) is the planned value of the work to be completed. It is the baseline for the approved scope, schedule, and cost. PV was previously called the Budgeted Cost for Work Scheduled (BCWS).
- Earned Value (**EV**) is the value of the work actually performed at a point in time. EV was previously called the Budgeted Cost for Work Performed (BCWP).
- Actual cost (**AC**) is the actual cost for the work performed. AC was previously called the Actual Cost for Work Performed (ACWP).
- Budget at Completion (**BAC**) is the original planned budget for the project. [Upon completion of the project, PV must equal BAC]. This is the total PV for the project. [The total of the PV is sometimes referred to as the performance measurement baseline or PMB], PMI, PMBOK® Guide 5th Ed., 2013.

After the performance baseline (integration of scope baseline, schedule baseline, cost baseline) has been developed, actual performance is measured against the baseline values. This study provides the key variances, performance indexes, and forecasting data to illustrate the use of EVM data to measure performance on projects. The following key formulas could be produced from the EVM data.

Measures of Cost Performance:

Cost Variance (CV) = EV – AC

CV gives a sense of how much you are over or under budget.
Positive CV indicates the project is under budget
Negative CV indicates the project is over budget
CV = 0 indicates the project is on budget [no gain, no loss]

Cost Performance Index (CPI) = EV/AC

CPI is a measure of performance (cost) efficiency. It measures how efficiently you have spent your money.
CPI > 1 means the project is under budget
CPI < 1 means the project is over budget
CPI = 1 means the project is on budget
CPI is generally expressed as follows: Assume your CPI is $0.67. This means that for every $1 spent, only $0.67 or 67C of work has been accomplished.

Measures of Schedule Performance:

Schedule Variance (SV) = EV – PV
SV gives a sense of how far you are ahead or behind schedule.
Positive SV indicates the project is ahead of schedule
Negative SV indicates the project is behind schedule
SV = 0 indicates the project is on schedule
Schedule Performance Index (SPI) = EV/PV

SPI is a measure of performance (schedule) efficiency. This measures the rate of progress.
SPI > 1: means the project is ahead of schedule
SV < 1: means the project is delayed or behind schedule
SV = 1: means the project is on target or on schedule as planned.

In addition to monitoring current project performance indicators, CPI and SPI indices can also be used to predict future performance trends. This means using EVM indicators to forecast future cost and schedule performance and progress on the project.

Forecasted Estimate at Completion (EAC_f)

Forecasted Cost Estimate at Completion uses actual costs-to-date plus an efficiency index to project final costs in large projects where the original budget is unreliable.

It is calculated as follows:

$$EAC_f = AC + [(BAC - EV) / CPI]$$

Revised Estimate at Completion (EAC_{re})

Revised Cost Estimate at Completion allows experts in the field to change original baseline durations and costs because new information tells them the original estimates are not accurate. It is calculated as follows:

$EAC_{re} = AC + ETC_{re;}$ and ETC = EAC – AC

Variance at Completion (VAC)

VAC shows whether the project will finish under or over budget. This is the variance on the total budget at the end of the project. Using this formula, 0 indicates that the project is forecasted to be completed on budget. A positive value indicates a forecasted under budget and a negative value indicates a forecasted over budget. It is calculated thus:

VAC = BAC – EAC

Figure 2 shows a sample cost/schedule graph with variances identified for a project at the current status report date, adapted from Larson and Gray (2014).

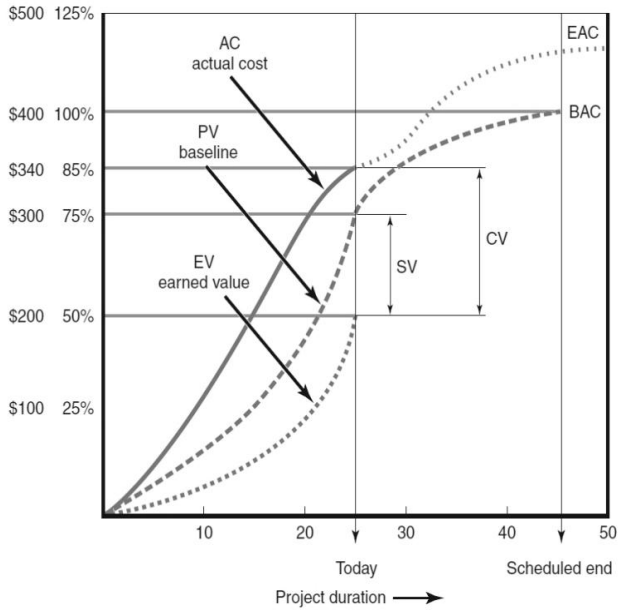

Figure 2: Cost/Schedule Graph
Adapted from Larson and Gray (2014). Project Management: The Managerial Process

Using the data in figure 2 we can see that the project at the current status report date is 25 [let's say weeks]. The top line represents the actual cost (AC) incurred for the project work to date. The middle line is the baseline (PV) and ends at the scheduled project duration (45 days) and at the cost of $400. Note that BAC is the sum of all PVs. Therefore, 45 is the BAC on this S-curve diagram. The bottom line is the budgeted value of the work actually completed to date or the EV. The dotted line extending the actual costs from the report date to the new estimated completion date represents the revised estimates of expected actual costs. Actually, the new completed date is 50 weeks and the revised actual cost is $500 dollars. This suggests that the costs at completion of the project will differ from what was planned. A closer look at this line reveals that the line extends beyond the BAC, ending at week 50 at the cost of $500.

With the extension of the project duration, using formulas provided earlier, therefore, the VAC = BAC – EAC = $400 - $500. This is in the negative territory or over budget (-$100). The graph also provides another interpretation using percentages. For example, at the end of week 25, 75% of the work was scheduled to be accomplished. However, at the end of week 25, only 50% of the work had been accomplished. Besides, the actual cost of work completed at this current status report date is $340 or 85 percent of the total project budget ($400). From this data, we can see that the graph suggests the project will have about 18 percent cost overrun and be five weeks late. Further, the current status report data shows the CV to be over budget by $140 (EV – Ac = 200 – 340 = -140). Also, the schedule variance is -$100 (EV – PV = 200-300 = - 100) which suggests that the project is behind schedule.

Similarly, we can see that the CPI (EV/AC) is $0.59 or 59%; and the SPI (EV/PV) is 0.67 or 67%. The project only completes 59c or 59% worth of work on every $1 it spends and for every $1 of work you planned to do, only $0.67 or 67C worth of work has been accomplished. Both the variances and indices are all unfavorable conditions. Caution needs to be exercised here when interpreting the SPI. The traditional EVM uses monetary units (dollars) to forecast duration units (weeks). This may not provide accurate status data.

The EVM variances have been consistently constructed so that negative variances are "unfavorable"; positive variances are "favorable"; and a variance of zero indicates an "on track" status. Similarly, cost and schedule performance indices of greater than one is favorable; less than one is unfavorable; and a CPI and SPI of one is on target in terms of cost and schedule. At this juncture, it should be noted that even though EVM provides insights into project cost and schedule status during project execution, it is more accurate at predicting future cost performance. EVM fails to accurately estimate the completion date and gives false schedule information near the end of the project. This flaw has been highlighted by various authors (Lipke (2003; Fleming and Koppelman, 2005); Henderson, 2003) among others.

Despite its popularity and wide acceptance, EVM has its critics. EVM is criticized for measuring schedule performance not in units of time, but rather in cost terms (e.g., dollars). As stated earlier, Lipke (2007) observes that at the completion of a project which is behind schedule, Schedule Variance (SV) is equal to zero, and the values say the project has perfect schedule performance. Of course, this is an incorrect indicator. In order to compensate for the flaws in the traditional EVM techniques, the extension of EVM was developed by Lipke. This EVM extension is called the Earned Schedule (ES).

Earned Schedule (ES) Methods in Practice

It should be noted that ES uses EVM data to describe schedule performance in units of time. Therefore, while EVM uses cost to measure duration, ES uses time to measure schedule performance. Therefore, ES is a more reliable approach to predict schedule performance on projects that finish late, or indeed early. The followings are key ES parameters:

AT: This is the actual time duration from the beginning of the project to status date.

PD: Planned duration is the final amount of periods that is planned to be needed for finishing the project. As such, PD is analogous to BAC, but referring to time (i.e., the total plan duration).

ES : This is duration from the beginning of the project to the date on which the PV should have been equal to the current EV.

SV_t: Schedule Variance time [this is sometimes called time variance (TV)] = ES - AT

SPI_t: Schedule Performance Index time = ES/AT

ETC_t: Estimate to Complete time = (PD – ES)/SPI_t

EAC_t: Estimate at Completion time = AT + ETC_t

$TSPI_t$: To-Complete Schedule Performance Index = (PD – ES)/(PD – AT)

Using the formulas given above, the author provides the following data and performs the schedule measurement calculations to illustrate ES application in practice.

Let assume ES = 3; AT = 5; PD = 12

SV_t (shown as TV in figure 3) = ES-AT = 3 – 5 = -2 (this means the project is 2 weeks behind schedule)

SPI_t= ES/AT = 3/5 = 0.6 (also < 1 therefore behind schedule)

ETC_t= (PD-ES)/SPI_t= (12-3)/0.6 = 15 weeks to completion at this point

EACt = AT + ETC_t= 5 + 15 = 20 weeks

TSPI = (PD – ES)/(PD – AT) = (12 – 3)/(12 – 5) = 1.3. This is indicative of the fact that the current schedule isn't feasible. Therefore, the work rate has to be higher than it currently is.

From the above calculations, we can conclude that this project is in trouble regarding schedule performance. It should be recommended that corrective actions be taken. It is critical to conduct an immediate review of this project, evaluate the underlying causes of the problems facing it, and make appropriate decisions promptly.

Figure 3 shows a graphical depiction with some key ES elements, adapted from Anbari (2011).

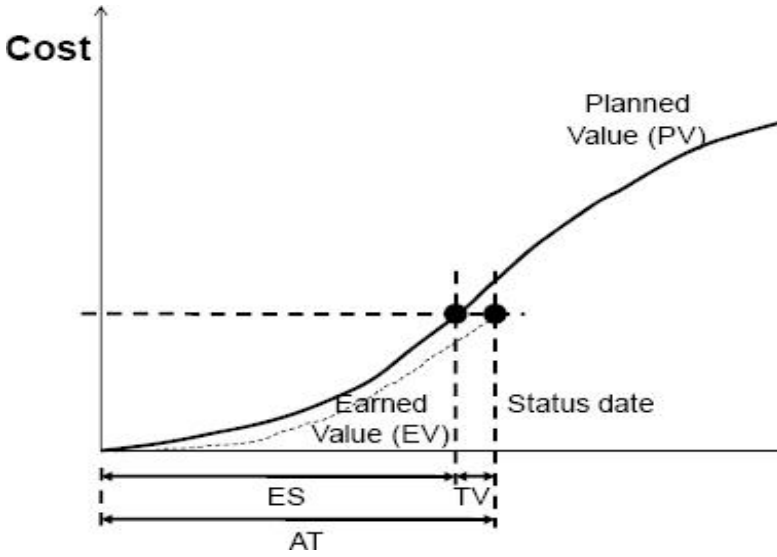

Figure 3: Components of the Earned Schedule
Adapted from Anbari (2011). Advances In Earned Schedule And Earned Value Management

Conclusions and Recommendations

Earned Value Management (EVM) has conventionally provided a good way to assess cost performance. However, it has been criticized for not properly accounting for schedule performance in terms of time. According to EVM, at the end of a project, SV would be equal zero and the SPI must equal 1, indicating absolutely perfect schedule performance, despite the fact that projects often run behind schedule. It is therefore concluded that, EVM is an imperfect measure of time performance. For this reason, the notion of Earned Schedule (ES) was developed to compensate for the shortcomings with EVM. The weakness in EVM as a measure of schedule performance is evidenced in the fact that EVM uses costs (for example, monetary units such as Dollars, Euros, Pula, Rand) to measure time units (for example, hours, days, weeks, months). It does not make sense to calculate \$100 – 25 weeks for SV_t.

Using the traditional EVM, variance analysis can enable the project manager to identify causes, determine impact, and decide whether corrective or preventive action for cost (CV = EV – AC), schedule (SV = EV = PV), and variance at completion (VAC = BAC – EAC) variances is required.

Nevertheless, by using cost data to measure schedule performance in the long-run, could provide misleading information.

Earned schedule (ES) is an extension of EVM. ES uses EVM data to determine schedule performance, as such, provides a more reliable source of schedule predictors for projects. The author of this study endorses Lipke's proposition on EVM as confirmed by Henderson and others who have identified ES as a superior alternative technique to measure schedule performance and progress on projects. As a result, the author recommends EVM as a better technique for measuring cost performance and ES as a superior technique for measuring schedule performance. Indeed, as Lipke emphasized, ES is a breakthrough analytical technique that resolves the EVM dilemma. Therefore, EVM technique has its place in project management practice as is ES technique. In light of these roles, therefore, both EVM and ES should be used in measuring progress performance on projects.

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