Earned Value, Clear and Simple

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Introduction

The term "Earned Value" is gaining in popularity around project management circles as if it is some wonderful new concept to be embraced. Yet, it has been in use since the 1960s when the Department of Defense adopted it as a standard method of measuring project performance. The concept was actually developed as early as the 1800s when it became desirable to measure performance on the factory floor. Today, it is both embraced and shunned, often in response to prior experience or stories told "in the hallway." The opponents will generally cite the cost and effort to make it work, and the limited benefit derived from its implementation. The proponents will cite the cost savings to the project overall, the improved analysis, communication and control derived from its implementation. No doubt, the two camps have vastly different experiences to formulate their perceptions.

This paper will explore the three major questions regarding this topic: What, Why and How? The purpose is to allay any fears the reader might have about applying this useful project management tool and to point the way to making it work. It is expected that the reader will gain a thorough understanding of the concept as well as a recipe for implementing Earned Value on his/her project.

What Is Earned Value?

When we speak of Earned Value, we generally are speaking of a methodology. While Earned Value is just one element of this methodology, it is the key element. The simplest way to think of Earned Value is to equate it with physical progress. As the name implies, it is something that is gained through some effort. In project management, this value is earned as activities are completed

Consequently, Earned Value is also a measure of progress. As we shall see later, there is a direct relationship between Earned Value and per cent complete. The attributes of Earned Value are threefold. First, it is a uniform unit of measure for total project progress or for any sub-element of the project. Second, it is a consistent method for analysis of project progress and performance. Third, it is a basis for cost performance analysis of a project.

If set up properly, Earned Value provides a uniform unit of measure for reporting progress of a project. The traditional units that are used include workhours and dollars. For labor intensive efforts, workhours are often considered adequate In such instances, the financial details of the remaining project cost are controlled by the accounting system. These costs include subcontractors, overheads and other direct costs. When the entire project cost is to be controlled from the project control system, then it is more effective to use dollars as the unit of measure for Earned Value. Since each labor hour has a price, dollars can be used to control labor as well. However, when using dollars, additional factors enter into the performance evaluation. This includes salary rate differences, escalation, overhead adjustments and differences, for example. Consider the effect if the plan calls for Tom, Dick and Harriet to do the work, but the actual work is performed by Lucy, Bill and Mary, who have different salaries. The dollar measure will include the effect of the salaries. For project financial control, this is good information. However, for project performance control, this information muddies up the waters.

Earned Value also is a consistent method for analysis of project performance. Suppose you ask the bricklayers and the carpenters how they're doing. You are likely to get different answers, influenced not only by how they are actually doing, but also by how they calculate their plan and their progress. As we shall see below in the discussion of "How," using Earned Value establishes a particular method for determining what the plan to date is and what the progress actually achieved is.

Earned Value provides the basis for cost performance analysis. If you want to know what's happening to the cost of your project BEFORE it is completed, you need to know what the planned cost at any time was and also what the cost of the completed work is. Referring to Figure 1, should this project manager be happy or concerned? It seems that the actual costs are considerably below the planned cost. This appears to be good news. However, unless you look at the planned cost of the completed work, you don't really know if this is good news or not. That is exactly the missing information that Earned Value provides.

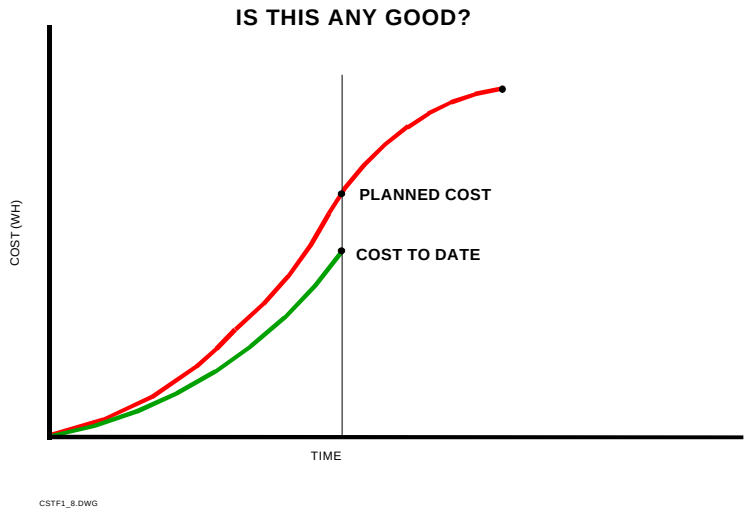

FIGURE 1 - TRADITIONAL COST ANALYSIS

In order to understand Earned Value thoroughly, we must become familiar with all the elements of the Earned Value method. Figure 2 provides an overview of these elements. While many people shy away from the acronyms used to label the elements, they quite accurately describe the elements. The project management practitioner should be familiar with the "alphabet soup." In this paper, we will use both the formal acronyms and more familiar terms to describe the elements.

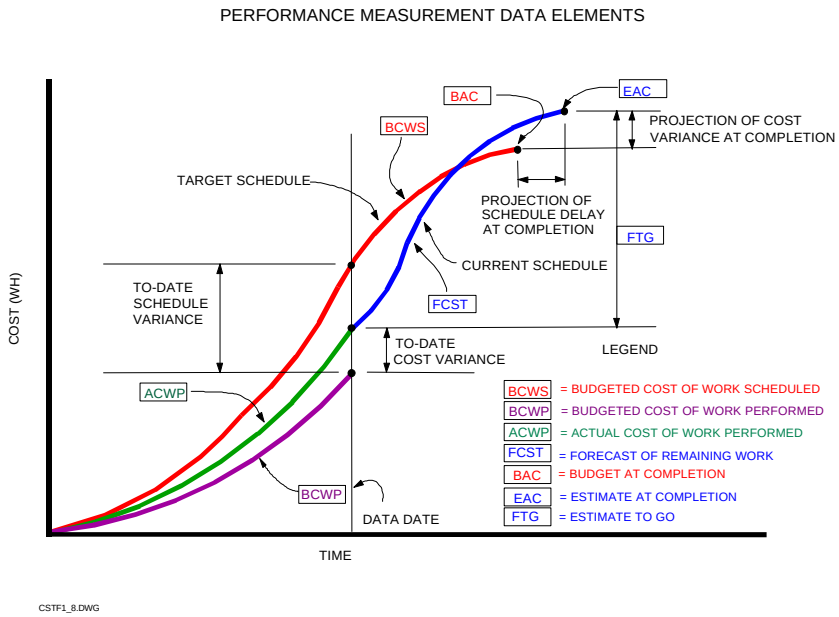

FIGURE 2 - EARNED VALUE ELEMENTS

The BCWS is the Budgeted Cost of Work Scheduled. Quite literally, it represents the budgets of the activities that are planned or scheduled to be completed. In the discussion of how to apply Earned Value, we shall see how this is developed and why the BCWS curve has the traditional S-curve shape.

The ACWP is the Actual Cost of Work Performed. Again, quite literally, it represents the actual cost charged against the activities that were completed. Later we shall see how we deal with activities that are in progress but not yet completed.

The BCWP is the Budgeted Cost of Work Performed. This is the traditional Earned Value that we speak of. It represents the planned or schedule cost of the activities that are completed. The distinction between the BCWS and the BCWP is that the former represents the budget of the activities that were planed to becompleted and the latter represents the budget of the activities that actually were completed.

These are the three major components of Earned Value. At any point in time, we have the planned work, the actual work and the cost of the actual work. This allows us to make the full analysis of our project progress and performance. Some of the other, related terms shown in Figure 2, include the Budget At Completion (BAC), the Estimate At Completion (EAC), the Schedule Variance (SV) and the Cost Variance (CV). We will learn more about these in the discussion on how to apply Earned Value.

Why Use Earned Value?

Before we consider the mechanics of Earned Value, let us examine the reasons for using it. After all, it does cost something to put it into operation. And, to do it right, it requires some effort on the part of the project team. If we review the discussion above on what Earned Value is, we have the main reasons for using it. Recall that Earned Value is a uniform unit of measure, a consistent methodology and a basis for cost performance analysis.

You might ask "What's so great about a uniform unit of measure?" Suppose that you are the project manager of a software development project. You're part way through your project and you wonder how things are. First, you want to know what per cent complete the project is. At a summary level, let's say that the project includes conceptual design, program specification, coding, documentation, user manual production, and debugging. Further, let's say that conceptual design and program specification are complete, coding and documentation are in process, manual production and debugging haven't started yet. So, how complete is the project? We've completed two out of six parts and are in process with two more. Does that mean we are 50% complete? Maybe, but, we don't know. What is each part worth? Does writing one line of program specification equal one line of code and they, in turn, equal one line in the documentation? How is one to equate the various parts?

Now suppose we determine that conceptual design is expected to take 200 wokhours, program specification writing 300 hours, coding 600 hours, documentation 100 hours, user manual 400 hours and debugging 500 hours. These labor "budgets" can easily be used as a weighting factor in establishing the worth of the various parts. That is exactly what Earned Value does. Since conceptual design and spec writing are done, we have "earned" 500 hours of value. For the in-process activities, we need to decide how we will earn the value. More on earning rules later. For now let's just say we are one quarter done with the coding and 10% with the documentation. We could then claim 150 hours for the coding and 10 hours for the documentation. The total earnings are then 660 hours. So, how complete is the project? Using Earned Value methodology, we would determine that the project is 31.4% complete (660 earned hours divided by 2100 hours of total project budget). Earned Value has allowed us to combine the progress of vastly different work efforts. The same thing works with any kind of project. Earned Value lets us combine cubic yards of concrete with square feet of forms, tons of rebar, feet of pipe, feet of conduit and cabling, etc. If we're in the banking business, Earned Value allows us to combine product development with market research, systems design, marketing and product introduction. In Hollywood, we can combine writing the screenplay with scouting for locations, set production, filming, editing, and marketing. By now you probably get the idea that Earned Value can be employed whenever your project involves defined tasks.

So much for a uniform unit of measure. What does consistent methodology do for me? Remember the bricklayers and carpenters? If you ask the carpenters how they are doing, you might get an answer such as: "We're doing fine, we've already used half the lumber you sent us at the beginning of the project. We'll have the rest used up by next week." The bricklayer might say: "We're doing great. Ninety per cent of the budgeted labor hours are spent, therefore we're 90% complete." Both parties might be correct, but what can you as the project manager do with that information? You can pass it along, but chances are that your management is not interested in the nitty gritty details, they want summary information. Using Earned Value, the bricklayers and the carpenters would measure the total quantities of bricks and lumber installed and compare that against the budgeted quantities to determine the per cent complete. Similarly, they would compare the installed quantities against the quantities planned to be installed up this point in time to determine if they are ahead or behind schedule. You can see that Earned Value has provided a method that both the bricklayers and the carpenters can use to report progress.

Now let us consider the third reason. Using Earned Value enhances the cost performance analysis of a project. Traditional cost analysis centers around the actual cost of the work that was completed. Therefor, much progress has been done to

collect the actual costs through the time charge and accounting systems that exist on practically all projects. What Earned Value brings to the process is a measure of the amount of work that has been done in a unit of measure that is consistent and comparable with costs. In other words, it allows us to compare "apples and apples" by using the same unit of measure for physical progress as for cost. Now we can more meaningfully assess whether the costs spent to date in Figure 1 are higher or lower than was planned.

How Do We Use Earned Value?

At this point we come to the practical part of actually seeing how Earned Value is applied on any project. There are 5 steps in setting up the Earned Value system on a project, and 4 steps in using it. These steps are described generically but they are the same for all projects. Each of these steps will be discussed in detail. To set up the Earned Value system:

1. Establish the Work Breakdown Structure (WBS) to divide the project into manageable portions.
2. Identify the activities to be scheduled that represent the entire project.
3. Allocate the costs to be expended on each activity.
4. Schedule the activities over time.
5. Tabulate, plot and analyze the data to confirm that the plan is acceptable.

To use the information generated by the Earned Value calculations:

6. Update the schedule by reporting activity progress.
7. Enter the actual costs on the activities.
8. Execute the Earned Value calculations, print and plot the reports and charts.
9. Analyze the data and write the performance narrative.

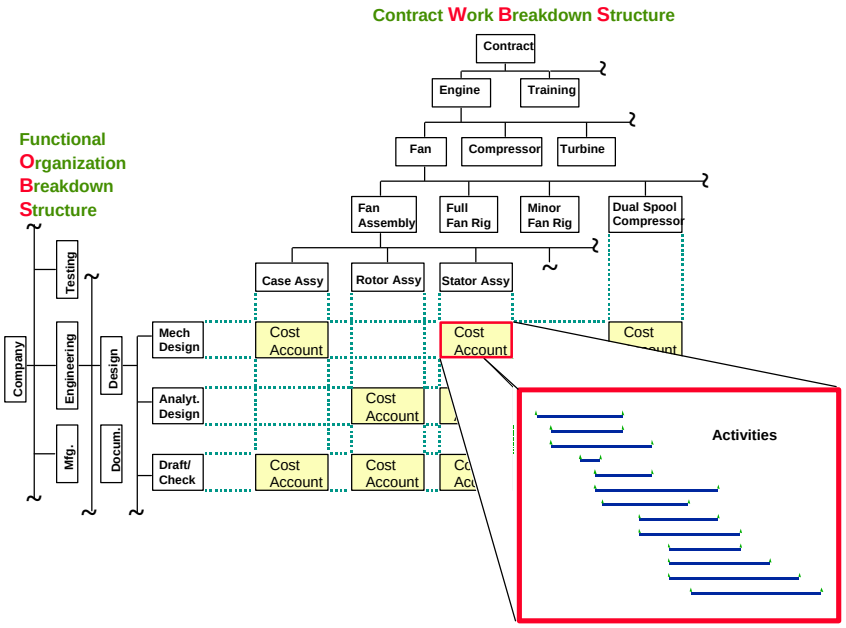

FIGURE 3 - WORK BREAKDOWN STRUCTURE

Step 1: Establish the WBS The WBS is the roadmap for analyzing the project progress and performance. It provides a multi-level structure for analyzing the project at varying degrees of detail. A properly defined WBS also provides that each element of the structure at each level is the responsibility of an individual who has management authority over that element and all the elements that roll up into that element. Furthermore, the WBS must contain the full scope of the project. Otherwise, the information generated will not represent the total project. The WBS is generally a hierarchical structure in

which each lower level element rolls into one and only one element at the level above it. The bottom level of the WBS should be the activities of the project. Figure 3 illustrates this. The key here is that each element has a responsible individual identified with it and each element represents a part of the project that someone or more people are interested in monitoring.

While this personal responsibility might bring to mind an Organizational Breakdown Structure (OBS), the WBS should not be confused with an OBS. Either structure can function as the framework for analyzing the project performance. However, an OBS is generally employed in a matrix organization where the functional management of the organization wants to analyze the performance of their functional unit on the project. The WBS is organized along the component lines of the project. For example, the project team member who is responsible for the Fan Assembly in Figure 3, has components (cost accounts and activities) in several engineering disciplines within the OBS. On the other hand, the Mechanical Design Manager in the OBS is interested in all the mechanical elements of all project components.

Step 2: Identify The Activities The second step is to identify the activities of the project. The WBS provides the framework for identifying the project components. As illustrated in Figure 3, each activity should be assigned to one element in the WBS. The completion of this step will produce the project schedule of activities, typically in a CPM network.

Step 3: Allocate The Costs The third step is to identify and allocate the costs to be expended for each activity. Since an activity represents a finite effort within the project, it has a duration of time and it requires the expenditure of some resources. The practitioner needs to decide whether to use labor resources only, such as work hours, or to use dollars and load all project costs into the schedule. The allocation of resources (costs) requires a choice of the degree of detail with which one will allocate the resources. These options include linear spread across the duration of the activity or use of a curve to approximate the expected expenditure during the activity's execution. These curves have an unlimited variety of shapes, the most common ones being symmetrical bell shape, front loaded triangle, back loaded triangle, equal triangle, lump sum at the beginning or end of the activity. However, detailed discussion of the application of resource curves is beyond the scope of this paper.

Step 4: Schedule The Activities The fourth step is to calculate the schedule of the activities. This step generally provides the spread of the resources over the entire time duration of the project. It generates the traditional S-curve of the project plan or baseline,also called the BCWS Curve.

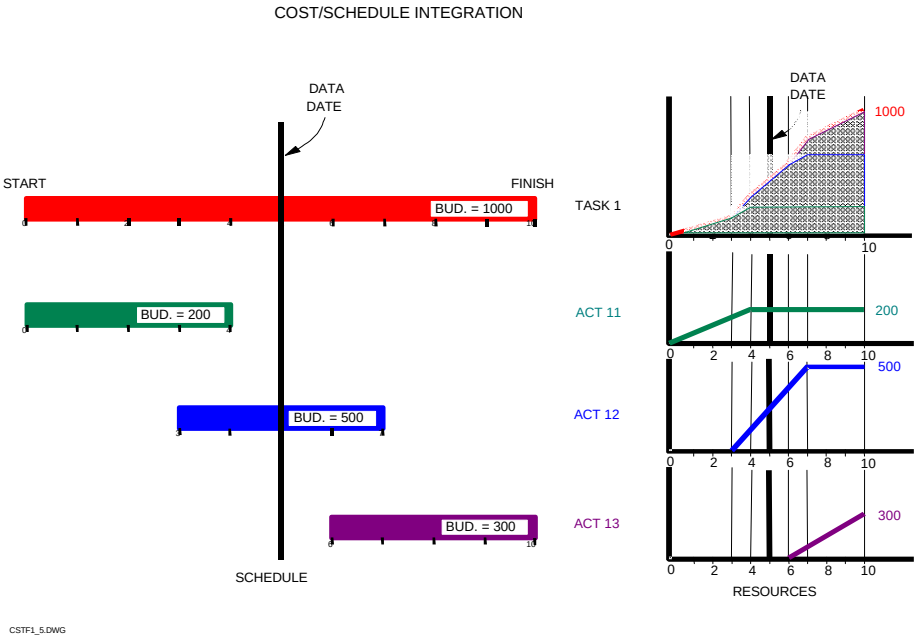

FIGURE 4 - RESOURCE LOADING THE ACTIVITIES

Step 5: Tabulate, Plot and Analyze The final step is to tabulate and plot the information that was loaded and then to analyze this information. The purpose is to assure that the allocation of resources is properly planned. This includes analysis of individual resources to see if the maximum requirement during any time period is available. It also includes review of cash flows, if dollars are entered, to see if the financing plan for the project supports the schedule. Third, it provides a review to see that all project resources and costs that are budgeted are entered into the program. Of course, correction of any anomalies discovered during this step is implied to be a part of this step. Figure 4 represents a very simple illustration of this process. It also illustrates with this very simple example, that the result is the traditional S-curve.

Once these five steps are completed, the project team will have the basis for conducting periodic analysis of the project progress and performance. That process is explained in the next four steps.

Step 6: Update the Schedule The first step in the periodic process is to update the schedule with the period progress. This is generally done whether Earned Value is used or not. The project schedule activities are reported as started, completed or with a remaining duration, as appropriate. The per cent complete of unfinished activities should also be reported. Here is where the practitioner should avoid subjectivity. For physical work it may be easy to determine the per cent complete. If 1000 cubic yards of concrete are planned to be poured and 300 yards have been done to date, then the activity is 30% complete. For efforts that are not so easily measured, special earning rules might have to be employed. Full discussion of earning rules is also beyond the scope of this paper. Two examples are presented to illustrate the point. One common rule is to report per cent complete according to completed milestones within the activity. For example, if the activity is the creation of a design drawing, progress might be reported as follows: 10% when the preliminary research and background study are completed, 20% when the drawing draft is completed and passed on to drafting, 40% when the first draft is printed, 50% when the first draft is reviewed, 60% when the second draft is completed, 75% when the client review is completed, 90% when the final draft is completed and 100% when the drawing is issued for construction. The key in defining this kind of rule is that each "milestone" is discrete, and its achievement is easily recognized by such evidence as transmittal memos.

A second common rule that is quite effective when the project has several thousand activities is to use the 50-50 rule. In this rule, each activity is considered 50% complete when its start date is reported and it is 100% complete when the activity finish date is reported. Reporting progress provides the basis for the Earned Value calculations

Step 7: Enter The Actual Costs The second step in the periodic process is to enter the actual costs into the schedule. This information comes from the time sheets and invoices to the project. Whether the data is entered manually or electronically is a matter of choice, depending on the degree of integration between the company's financial accounting system and the project control systems. In any case, it is necessary to determine which costs are to be allocated to which activity. By proper integration of the financial and project accounting systems, this process is facilitated to the point of total automation. However, human analysis of the actual data is recommended to assure that improper data doesn't inadvertantly enter the system.

Step 8: Calculate, Print And Plot The next step in the periodic process is to calculate the Earned Value and to print reports and plot charts for analysis. The Earned Value is simply the per cent complete of an activity times its budget. This provides the key value in the Earned Value process. Other calculations include the schedule and cost variances, performance indices, estimates at completion and per cent complete of the upper elements of the WBS. Referring to Figure 2 will aid in understanding the following calculation discussion.

Schedule Variance (SV) is the Earned Value minus the planned budget for the completed work (BCWP-BCWS.

Cost Variance (CV) is the Earned Value minus the actual cost (BCWP-ACWP.

Performance indices are merely ratio expressions of the SV and CV. The Schedule Performance Index (SPI) is the Earned Value divided by the planned value (BCWP/BCWS).

The Cost Performance Index (CPI) is the Earned Value divided by the actual cost (BCWP/ACWP).

The Estimate At Completion (EAC) is a number of great interest each update cycle. It indicates where the project cost is heading. Calculating a new EAC is one of the great benefits of Earned Value. However, the actual formula to use for this calculation is a matter of much discussion. For the purpose of this paper, we will look at the basic impact of cost performance on the EAC. The intent is to show that Earned Value is a key forecasting tool for managing a project. Referring

to Figure 5, let us assume a project is having some trouble meeting its cost goals. At the data date, the actual cost is greater than the planned cost for the completed work (ACWP > BCWP). If performance continues at the same trend, we can easily see that at completion the actual cost (EAC) far exceeds the budget (BAC). The simplest formula for arriving at the EAC at the time of the data date is:

$$EAC = \frac{(BAC-BCWP)}{CPI} + ACWP$$

This formula determines the unfinished or unearned work (BAC –BCWP) and divides it by the CPI. To that is added the sunk cost, or the cost of the completed work (ACWP). From this we can see that poor cost performance. a CPI less than 1, would result in an EAC that is greater than the BAC. More complex formulas are used which factor the CPI to give it more or less influence on the EAC.

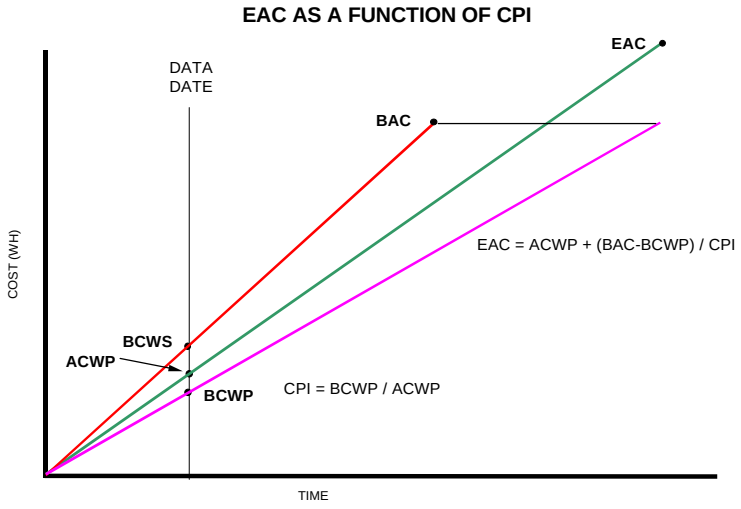

FIGURE 5 - FORECASTING THE ESTIMATE AT COMPLETION

One more calculation is noteworthy since it is specifically made possible by the use of Earned Value. That is the per cent complete at the upper levels of the WBS. While progress is typically recorded at the activity level of detail (the bottom of the WBS), those responsible for the project at higher levels of the WBS want to know the same kind of information as the "activity managers." The process involves rolling up the data through the WBS. Budgets and actual costs are easy to roll up; simply add the values of the lower elements to get the value of the parent element. However, how does one roll up per cent complete? The answer is, of course, Earned Value. Since Earned Value is directly related to per cent complete, one can simply add the Earned Value of the lower elements to get the value of the parent element. Then, one can use this information at the upper levels to back calculate the per cent complete of the upper elements. Just as Earned Value equals the BAC times the per cent complete at the lower levels, so does per cent complete equal BAC divided by Earned Value for any element in the WBS.

Step 9: Analyze and Report. The final step in the Earned Value process is to analyze the data and the report the result of that analysis. The scope of this paper does not allow detailed discussion of the analysis process. However, from the above, the reader can recognize the significance of the various calculations discussed above. How he or she interprets that information is left to his or her common sense.

Conclusion

With the above presentation, we have explored the What, Why and How of Earned Value. We have seen that Earned Value is a tool for improving the performance analysis of a project, by: providing a uniform unit of measure for project progress, enforcing a consistent method for analysis and providing a basis for cost performance analysis of the project. The reason for

using Earned Value is tied closely to what Earned Value is. The process of implementing Earned Value is organized into five steps and the process of periodic analysis consists of four additional steps. While the manipulation of the vast amount of data that is involved may seem daunting, the use of available computer tools designed for the purpose, make the implementation a relatively simple "cookbook" procedure. If the reader takes one thing away from this paper, it should be that Earned Value simply represents the budgeted value of the completed work and is directly related to the per cent complete of the activity or WBS element under consideration.