Earned Value Project Management
A Powerful Tool for Software Projects

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Earned value can provide any project manager with an early warning tool that sends out a signal from as early as the 15 percent completion point on a project. This signal allows the project manager to forecast the final required funds needed to finish the job within a narrow range of values. If the final forecasted results are unacceptable to management, steps can be taken early to alter the final requirements. The end benefit is that software projects can be completed that contain more final features—if the project's management monitors the true cost performance from the beginning of the project.

Over the last three decades, a proven but yet underutilized project management technique has emerged and taken its place alongside other valuable tools: *earned value*. In its formal application, it has been found to be an effective device to oversee and manage major new systems acquisitions by U.S. government agencies. In a more basic form, earned value can be a useful technique in the management of any project—including, and in particular, software projects.

Earned value requires that the project be fully defined at the outset and then a bottom-up plan be created. This allows measurement to take place during the entire period of performance, from 1 percent to 100 percent of the project's lifecycle. The power in this tool is that it provides accurate and reliable readings of performance from as early as 15 percent into the project. As shown in Figure 1, any project manager can use these performance readings to predict how much it will cost to complete the project within a narrow band of values. If these early warning signals convey unacceptable readings to the project manager, steps can be immediately taken to avoid the undesired results.

This technique is of particular interest to software project managers. No longer must software projects use up all their resources before there is a harsh realization that much of the work has not been completed, forcing features to be dropped to stay within the added budget authorized by management. Earned-value project management can be most helpful to any software project manager who has made a firm commitment to complete all the features within a definitive schedule and for a finite amount of funds.

Introduction to the Earned-Value Concept

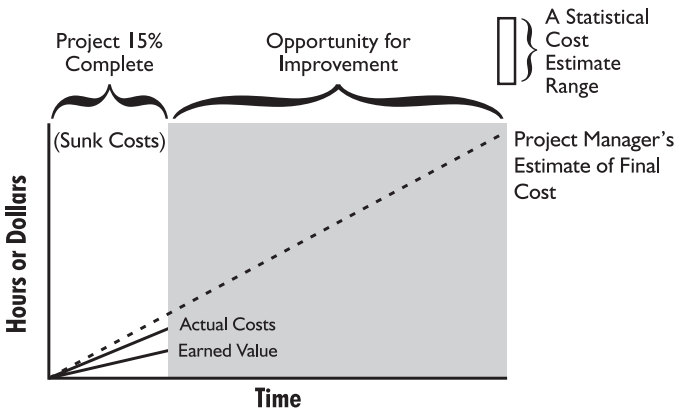
Earned value has been mandated by the U.S. government for decades in an inflexible, formalized manner that has kept many organizations from attempting to use the technique. This mandated, formalized version began in 1967 when the Department of Defense (DoD) issued a directive that imposed 35 Cost/Schedule Control Systems Criteria (C/SCSC) on all private industrial firms that wished to participate in future major government systems in which some type of cost-reimbursable or incentive contract was to be used. Thereafter, any time a new major system would be procured by the U.S. government in which the "risk" of cost growth was retained by the government, these 35 criteria had to be satisfied by the contractor.

The effect of the C/SCSC mandate was to require a formal version of the "earned-value" concept of cost and schedule management on selected major new projects. A certain minimum contract dollar value (in millions) and a minimum program duration (of 12 months or more) had to be present before the criteria were to be applied. Essentially, these earned-value criteria were intended only for major system procurements.

The C/SCSC concept has been consistently applied for over 30 years and has set the standard for major government systems acquisitions. Other government agencies in the United States and in other nations such as Australia, Canada, and Sweden have adopted similar earned-value criteria in the management of their major system acquisitions. A practical body of scientific management knowledge has been developed on the use of the earned-value concept, primarily compiled by the DoD and by the Air Force Institute of Technology (AFIT).

Although some people consider these 35 C/SCSC standards a Utopian ideal for all private firms to emulate, many within private industry have had difficulty employing these

Figure 1. *Cost risks can be managed with an "early warning" signal.*



rigid criteria on all their projects—particularly commercial projects. Their perception is that there are too many nonvalue-added requirements in the formalized C/SCSC for them to be universally employed on all their commercial projects.

Industry's acquired distaste for the C/SCSC implementation of earned value is unfortunate because earned value performance measurement provides a sound project management tool. When properly employed, it can give the project manager an early warning signal that the project is heading for a cost overrun unless immediate steps are taken to change the spending plan. The software world needs something less formal than the full C/SCSC, something that can be scaled downward and precisely tailored to fit broader project management applications. Today, it is likely that more than 99 percent of the projects in the world do *not* employ the earned-value cost management concept. Instead, to monitor costs status, they merely compare their spend plan to their actual costs, and that is unfortunate. There are opportunities to use a simplified form of earned value on any project of any size within the military or commercial sectors.

The Genesis and Evolution of Earned Value

To properly understand the earned-value concept, we must go back in time to the early part of this century and trace the origin of earned value as it came initially from the factory floor.

The Factory Floor in the Early 1900s

The earned-value concept originally came from industrial engineers in factories who for years have employed a three-dimensional approach to assess true "cost-performance" efficiencies. To assess their cost performance, they have been comparing their *earned standards* (the physical factory output) against the *actual costs* incurred. Then they compare their earned standards to the original *planned standards* (the physical work they planned to accomplish) to assess the schedule results. These efforts provided earned value in its most basic form.

Most important, the industrial engineers defined a *cost variance* as the difference between the actual costs spent and the earned standards in the factory. This definition of a cost variance is perhaps the litmus test to determine whether one uses the earned-value concept.

PERT/Cost 1962-1965

The Program Evaluation and Review Technique (PERT) was introduced by the U.S. Navy in 1957 to support the development of its Polaris missile program. PERT attempted to simulate the necessary work to develop the Polaris missile by creating a logic network of dependent sequential events. The initial focus of PERT was on the management of time and on predicting the probability of program success. But before PERT was accepted by program management in industry, the U.S. Air Force came up with an extension of PERT by adding resource estimates to the logic networks. *PERT/Cost* was thus born in 1962, and the initial PERT was thereafter known as *PERT/Time*.

The significance of PERT/Cost, however, was not the technique, but what evolved from it. The earned-value measurement concept was first introduced to the American defense contracting community when the government issued the *DoD and NASA Guide to PERT/Cost* in 1963, which provided a simple definition of earned value. Instead of relating cost plans to cost actuals, which had been the custom, PERT/Cost related the *value* of physical work performed against the cost actuals to determine the utility and benefits from the funds spent. What was *physically accomplished* for what was *spent* was a simple but fundamentally important new concept in program management.

For various reasons, the DoD gave up on the PERT/Cost technique in the mid-1960s but correctly held on to the earned-value concept. When the DoD formally issued the C/SCSC in 1967, the earned-value concept was solidly contained therein.

C/SCSC 1967 to 1996

Since the issuance of the C/SCSC by the DoD, the concept's application has been limited only to contracts in which the government has retained the risks of cost growth, i.e., on cost- or incentive-type contracts and subcontracts. Perhaps the most significant aspect of C/SCSC employment has been the body of scientific knowledge that has been accumulated in its use on major highly technical projects. The DoD has been accumulating data on the use of earned value to assess project performance and has been using the results attained to predict final cost and schedule results with amazing accuracy.

Earned Value Management Systems Criteria 1996 to Present

After years of earned value being imposed on industry by the government as a unilateral mandate, private industry asked for and was allowed to have a say in the wording of the requirements being imposed on them. In 1995, private industry, as represented by the National Security Industrial Association (NSIA), was allowed to assess the utility of the earned-value criteria.

After a year-long study, the NSIA subcommittee came up with its version of the criteria, reworded significantly to be more palatable to the project management community. The industry standard was called the Earned Value Management System (EVMS) and the number of criteria was reduced from 35 to 32. This major development was endorsed by the DoD in December 1996.

However encouraging these recent advancements may be, going from 35 to 32 criteria still leaves the earned-value concept with far too many nonvalue-added requirements. We believe the earned-value concept will never be universally accepted by project managers in its current form, embedded as a part of the 32 formal EVMS criteria. There are too many rules and terms one must master to employ this approach. Instead, what is needed is a return to the simple concept that originally came from the industrial factory floors. The industrial engineers did not use checklists and interpretations to employ their concept;

rather, they used common sense to determine what was needed and what did or did not work.

Listed below are 10 earned-value "musts" that, when followed, capture the critical essence of the earned-value concept and enhance the management of all projects, large and small, from any industry.

Ten Musts to Implement Earned Value on All Projects

Define Work Scope

You must define 100 percent of the project's work scope using a work breakdown structure (WBS). Perhaps the most critical and most challenging requisite to employing earned value is to define the project's total work scope. This is a difficult task for any project, and particularly so for software projects. Yet, if you do not define what constitutes 100 percent of the assumed work, how can you measure the project's performance in a definitive way? Without a 100 percent reference point, how can anyone ascertain whether you have completed 10 percent, 20 percent, or 25 percent of a job?

Realistically, no one can define a new job with absolute precision, but you must make some intelligent assumptions about a new project to quantify the work with sufficient confidence that the defined effort can be planned, scheduled, and estimated with some degree of certainty. Anything less, and management must commit to a job by authorizing a "blank check" for the project.

How does one define a job when specific details are often lacking? There are no absolute answers, but one of the most useful of all tools available to any project manager is the WBS. The WBS is to the project manager what the organization chart is to the executive—it allows the project manager to define a new endeavor by laying out all the assumed work, then decomposing each task into measurable work packages. Once the WBS is assumed to constitute a reasonable portrayal of the new project, it can be used to take the next steps in the project planning process, including the make-or-buy analysis, risk assessment, planning, scheduling, estimating, and authorization to proceed.

Create an Integrated Bottom-Up Plan

You must combine critical processes, including defined work scope, schedule, and estimated resources, into an integrated bottom-up plan of detailed measurement cells called Control Account Plans (CAPs). Earned value project management is implemented within detailed CAPs, which therefore constitute formal bottom-up project planning. The individual CAPs represent the integration of all critical processes such as work scope, planning, scheduling, estimating, and authorization.

The performance measurement will take place within the detailed CAPs, and the total project's performance is the summation of what was reflected in the detailed CAPs. In essence, each project CAP is a subproject of the total project that is managed, measured, and controlled by a CAP manager.

Formally Schedule CAPs

Each of the defined CAPs must be planned and scheduled with a formal scheduling system. This is perhaps the single most critical tool required to implement earned value. The project's scheduling system will portray the approved work scope, which is carefully placed into a specific timeframe for performance. In earned-value vernacular, this scheduled work will constitute the project's *planned value*. As performance takes place on the project, the portion of the planned value that is physically accomplished becomes the earned value. Both the planned value and the resulting earned value must use the same metrics to measure their performance.

The project's scheduling system is, therefore, critical to the employment of earned value because it is the vehicle to represent the project's scope, planned value, and earned-value measurement. The *project master schedule* is vital to the project because it constitutes the project manager's specified planned value for everyone to follow.

Assign Each CAP to an Executive for Performance

Each of the defined CAPs must be assigned to a permanent functional executive for performance. This assignment effectively commits the executive to oversee the performance of each CAP. Projects are by their nature transient within any firm's permanent organizational structure—they are authorized, implemented, and performed, then eventually go out of existence. Many (perhaps most) of those who manage the detailed performance that takes place within the CAPs will not carry the formal title of "manager" within the firm's permanent organizational structure; rather, many or most of these CAP managers are functional employees temporarily assigned and matrixed into the project by one of the permanent functional organizations. To secure a firm commitment from the functional executives who have the authority and resources to make the plan happen, it is wise to have each of the defined project CAPs essentially adopted by a senior function person with a title such as vice president, director, or manager.

Establish a Baseline that Summarizes CAPs

A total project performance measurement baseline must be established, which represents the summation of the detailed CAPs. The next required step is to form a total baseline against which project performance may be measured. Such baselines must include all defined CAPs plus any management (contingency) reserves that may be held by the project manager. If management reserves are not given to the project manager but are instead controlled by a senior management committee, they should be excluded from the project performance baseline.

On a commercial-type contract, the baseline may include such things as indirect costs—and even profit or fee—to match the total authorized project funds. Internal projects will typically not contain indirect costs, profits, or management reserves. Most internal project

baselines will be the sum of the defined CAPs.

Measure Performance Against Schedule

Periodically, you must measure the project's schedule performance against its planned master project schedule. The formally issued and controlled project master schedule constitutes the project's planned scope. Each task described on the project master schedule can be loaded with estimated resources, such as hours or dollars, which are embedded within the authorized CAPs. As performance takes place within the CAPs, you can quantify the relationship between the value of the work scheduled as compared to the value of the work accomplished. The difference between the work scheduled and work accomplished constitutes the *schedule variance* in earned value.

A negative schedule variance means that the value of the work accomplished does not match the value of the work scheduled, i.e., the project is falling behind in its scheduled work. Each behind-schedule task can be assessed regarding its criticality to the project. If the late task is on the critical path, or if the task carries a high risk to the project, efforts can be made to get the late task back on schedule. Conversely, if a task has positive variance or is not considered a high risk to the project, added resources should not be spent to accelerate its performance.

Measure Cost Efficiency Against the Costs Incurred

You must periodically measure the project's cost performance efficiency rate, which represents the relationship between the project's earned value performed and the costs incurred to achieve the earned value. The single most important benefit of employing earned value is the cost efficiency readings it provides. The difference between the value of work performed and the costs incurred to accomplish the work provides the cost-efficiency factor. If you are spending more on the project than it receives in value, this reflects an overrun condition. Absolute overruns have been found to be nonrecoverable. Overruns expressed as a percentage value have been found to deteriorate unless the project takes aggressive actions to mitigate the condition.

Perhaps of greatest benefit, the cost efficiency rate has been found to be usably stable from the 15 percent point of a project completion and progressively more stable as it goes from the 20 percent to 30 percent to 40 percent completion point. Therefore, the cost efficiency factor is an important metric for any project manager or enterprise executive to monitor.

Forecast Final Costs Based on Performance

Periodically, you must forecast the project's final cost requirements based on its performance against the plan. One of the more beneficial aspects of the earned-value concept is its ability to independently forecast the total required funds at the end of a project, commonly called the "estimate at completion." Based on project performance against the plan, a project manager can accurately estimate the total funds required to finish the job within a finite range of values.

These statistical estimates are something like a grass-roots sanity check against estimates based more on wishful thinking because they provide a more realistic estimate of the values needed to finish the job—unless someone has a preconceived notion of what that value should be. As reflected in Figure 1, if the earned-value statistical estimates are greater than the "official" project estimates to complete the project, someone in a senior management position should reconcile these professional differences of opinion.

Manage Remaining Work

You must continuously manage the project's remaining work. The results achieved to date on a project, good or bad, are in effect "sunk costs"—gone forever. Thus, any improvements in performance must come from future work—tasks ahead of the latest status date. Earned value allows the project manager to accurately measure the cost and schedule performance achieved to date. If the results thus far are less than desired, the project manager can exert a more aggressive posture on all future work. Earned value, because it allows the project to accurately quantify the value of its work achieved, allows the project manager to also quantify the value of the work ahead to stay within the objectives set by management.

Manage Baseline Changes

You must continuously maintain the project's baseline by managing all changes to the baseline. The project performance measurement baseline you put in place at the start of the project is only as good as your management of all proposed changes to the baseline during the duration of the project. Any performance baseline quickly becomes invalid if you fail to incorporate changes into the approved baseline either by the addition to or elimination of added work scope.

All new changes of project work must be addressed either by the approval or rejection of changes. For the initial baseline to remain valid, every change must be closely managed. Maintaining a baseline is as challenging as the initial definition of the project scope at the start of the project.

Conclusion

The earned value project management concept as a part of the more formal C/SCSC or EVMS has been demonstrated to be an effective technique in the management of major projects. Unfortunately, most of the experience with the concept has been restricted to those applications where the U.S. government has imposed the technique on major new systems acquisitions for which it retains the risk of cost growth.

However, the best opportunities for earned-value employment may well lie in the management of thousands of smaller projects that are being directed by people who may well be unaware of earned value. We believe the concept should be considered any time the risk of cost growth resides with a project manager, any time a lump sum or fixed price contract is used, and on all in-

house funded developmental projects where a firm commitment is made to management. It should be considered any time a project manager could benefit from receiving an early warning cost signal in time to alter the ultimate direction of a project. Software projects can especially benefit from the employment of a simple earned-value approach. ◆

About the Authors

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