

Gaining Confidence in Using Return on Investment and Earned Value

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The terms “earned value” and “return on investment” (ROI) are frequently heard in the world of project management; however, they are often used incorrectly or inconsistently. This article summarizes the major principles and purposes of these management tools with the intent on moving them into the mainstream of proper use.

Throughout the Department of Defense (DoD) and private industry, the terms “return on investment” and “earned value” are becoming more commonplace. Their use also is becoming more appropriate, visibly demonstrated, and validated. These terms tend to frustrate some program managers and corporate executives, while other organizations revel in their daily application. It is interesting that some organizations value these terms, while others disregard or minimize their use. At the heart of this conundrum lie a variety of statements and questions that range from skepticism to downright confusion:

- **Is the definition believable?** “This project showed an ROI of 1,421 percent over three and a half years with a payback period of 0.23 years.”
- **Are you sure?** “With respect to project status, I believe we are right on course and are actually under-running our costs.”
- **Lack of understanding.** “Considering project’s nature, what is the best method to compute our ROI?”
- **Complexity and confusion.** “How in the world can I compute earned value on *that* task?”

In working with a variety of organizations, the Software Technology Support Center (STSC) has discovered the equal variety of approaches to ROI and earned value. Some organizations tend to only intellectually capture and display the information, others use inappropriate or incorrect definitions to support marketing tactics, while others honestly struggle with accurate defini-

tions but value these tools as legitimate management approaches.

As an example, the STSC recently provided support to a DoD organization in the inspection of a software development plan. The inspection was carefully planned, then implemented over a short time frame. At the outset, ROI and earned value were not a specific focus of the effort, and detailed measures were not defined. However, as the inspection neared completion, a sufficient amount of data was generated that enabled the organization to compute rough estimates for both earned value and ROI.

By deliberate design, the partitioning (chunking) of the document, the allocations of inspection assignments, and the regular monitoring of progress enabled a clear estimate of the earned value achieved at different points during the inspection. Once the data was baselined, earned value was a straightforward computation that demonstrated a progression toward successful completion of the inspection project.

The organization also was pleased with a relatively accurate ROI estimate of just over a ratio of 4-to-1. This ROI measure was based on actual hours invested in inspecting the document and estimated hours saved in downstream costs if the discovered defects had not been detected. This estimate worked well for this activity and measurably justified the expenditure of effort. However, since it was unique to this organization and this effort, mapping it to another situation would be inappropriate. Although not specifically quantifiable, the ROI was influenced by

strong leadership, an insistence on progress tracking, and the commitment of the inspection team—all semiunique intangibles.

Earned value and ROI have been called management indicators, metrics, measurements, etc. Although ROI is typically used as an overall indicator of project success, it is supported by the consistent tracking and monitoring of one of the “smaller scale” (but more quantifiable) ROI measures—earned value. Conscious and regular earned-value measurements point toward and validate any stated ROI. Therefore, the proven utility and importance of these two tools—used not only separately but also together—are reasons to understand them better. The following sections define the terms ROI and earned value, establish a context for their use, and discuss a few examples of how they might be applied.

Return on Investment

In its basic computation, ROI is stated as the *ratio of savings estimated or measured in a given effort by the cost incurred to accomplish that effort*. The difficulty in computing ROI is to determine what constitutes the *total savings* or *return* and what constitutes the *total investment*. Although much of the value that goes into the terms *total return* and *total investment* may be straightforward and measurable, these terms often include various intangibles that are not only valid but also crucial to an accurate measurement of ROI. Less tangible items could include customer confidence, competitiveness, effects of downtime, impact on productivity, and lost opportunities.

Common Terminology

A discussion of the terminology associated with ROI and earned value will assist in understanding their usefulness and fostering practical implementation. Note that the ROI terms and associated definitions were compiled in part from [1]; earned-value terms and associated definitions were compiled in part from [2] and [3]. See Figure 3 for a graphical representation of some of these terms.

ROI Terms

Payback Period – The amount of time following a project or improvement effort, either estimated or measured, during which the total investment of the improvement will be repaid by the savings it brings.

Investment – The estimated or measured total cost in hours, dollars, or other units that an improvement effort requires to be planned, executed, and completed.

Return on Investment – The total quantitative savings or return, in hours, dollars, or other measurable units, generated by an improvement effort, divided by the total cost of the improvement effort.

Cost of Quality – A popular factor in the computation of ROI for quality-related improvement efforts. Cost of quality is the cost of not doing things right the first time, and may include preparation costs, execution costs, and follow-up costs for the effort as well as other measures that contribute to the quality effort.

Cost of Conformance – The estimated or measured cost for an organization or project to conform to stated requirements. Cost of conformance generally includes assessment costs and prevention cost.

Cost of Nonconformance – The estimated or measured cost incurred by an organization or project for reworking an effort or project because things were not done correctly the first time.

Earned-Value Terms

Budgeted cost of work scheduled (BCWS) – The sum of the budgets for all planned work scheduled to be accomplished within a given period.

Budgeted cost of work performed (BCWP) – Also called the earned value, it has three definitions: (1) The estimated (in contrast to the planned) value of work performed as of a specific point in time, (2) a method for measuring project performance comparing the amount of work that was planned with what was actually accomplished to determine if cost and schedule performance is as planned [2], and (3) the sum of the budgets for completed work and the completed portions of open work [3].

Actual cost of work performed (ACWP) – The costs incurred in accomplishing the work performed.

Schedule variance (SV) – The numerical difference between the budgeted cost of work performed and the budgeted cost of work scheduled.

Cost variance (CV) – The numerical difference between the budgeted cost of work performed and the actual cost of work performed.

Schedule performance indicator (SPI) – The planned schedule efficiency factor representing the relationship between the value of the initial planned schedule and the value of the physical work performed.

Cost performance indicator (CPI) – The cost efficiency factor representing the relationship between the actual costs expended and the value of the physical work performed.

Budget at completion (BAC) – The sum of all budgets allocated to a project. The BAC is synonymous with the performance measurement baseline.

Performance measurement baseline (PMB) – The time-phased budget plan against which project performance is measured. The PMB is synonymous with the BAC.

When such complexities are factored in, the ROI computation usually changes, considering diverse elements inherent in the improvement effort it is meant to quantify. Therefore, because it is less costly to compute an estimated ROI (because of the intangible values), one could reasonably conclude that most stated ROIs are heavily estimated rather than measured. This causes difficulty in comparing ROI information.

To better understand the ROI concept, examine different uses and approaches to compute and report ROI. Any organization that desires to successfully deliver products or services over a long term requires a positive ROI. It follows that good management planning will outline steps necessary to reach such an ROI. This includes select-

ing the proper method to compute ROI, accurately reporting ROI, identifying necessary success factors that relate directly to your product and organizational structure, then strategically leveraging them.

Improvement-Based ROI – Depending on the type of improvement being attempted, approaches to compute ROI may be drastically different. The end product of one type of improvement may yield highly quantifiable, or at least estimable, results. For example, research of the potential benefits of document inspections has led to estimated hourly savings to find and fix defects upstream in the lifecycle as opposed to finding and fixing them in later development phases [4, 5]. The estimated savings per defect, although

questioned by some, translate directly to personnel hours and dollars saved by the inspection process improvement, due to earlier and more efficient detection and removal of defects.

Conversely, the insertion of a network management system, for example, may not yield an easily quantifiable ROI. Although there would be some readily quantifiable costs (design, development, operation, acquisition, training, and maintenance), many critical costs and benefits may be far less tangible, as discussed earlier.

In such cases, the difficult task for managers is to quantify these intangibles. Although difficult, the task is not impossible. One often overlooked method is the strategic use of customer satisfaction surveys [6]. For example,

frequently surveying key customers might reveal that when the overall satisfaction level exceeds a given threshold, customers are a certain percentage more likely to request additional support, add task orders to contracts, and rule favorably on contract incentives. Similar information gathering at the marketing level may reveal that an estimated dollar value of contracts were won due in part to the improvement effort and its effect on the organization's capabilities and performance. Understanding what the intangibles are and how they affect the organization is key to understanding how to compute ROI for them.

Reporting ROI – In many cases, the method of reporting ROI is as much a key to success as the computation of ROI. For this reason, organizations often report ROI measurements along with additional reference points, such as payback period, risk mitigation strategies, and forecasted ROI estimates. Upper management is continually interested in the “quick win” or “low-hanging fruit” in an improvement effort. Factual and substantiated estimates that reinforce a stated ROI value provide that benefit to management—benefits that go a long way toward continued sponsorship of the effort, professional credibility, and willingness to accept risk and continue in improvement initiatives.

As members of an organization become better at the computation and management of ROI, they become more adept in computing the amount of time in which an improvement will pay for itself. The organization will be more able to identify risks to the effort and propose mitigation that will preserve and even increase the ROI. In this optimized environment, the organization will be able to estimate with considerable accuracy the ROI expected in the coming months and years as the improvement effort progresses.

ROI Success Factors – Organizations that are likely to achieve the best ROI are those that embrace it as a strategy [6]. The natural product of any strategy is a plan or road map that, if followed, will achieve some measure of

success. The following elements will contribute to such a plan.

- Use the principles of cost-and-benefit analysis to completely identify all potential costs and savings expected as a result of the improvement effort.
- Rank all costs and savings of the effort with respect to the severity or importance of their impact.
- Identify the subset of costs and savings that will be used to compute the ROI.
- Develop a plan to monitor and manage the selected costs and savings.
- When computing ROI, plan for the inclusion of input from people who have a direct understanding of the non-tangible benefits or savings, e.g., marketing, engineering, or contracting departments.
- Frequently communicate about the plan with all relevant parties.
- Compute and use additional supporting metrics such as payback period.
- Determine strategies to improve the estimated and forecasted ROI for the coming months or years.
- Strengthen sponsorship by including key people in ROI plans and management activities.

Earned Value

The earned value approach to project tracking originated over 100 years ago as a result of improvement efforts in the operation of factories and has gained considerable popularity in the last few decades. Earned value was formally proposed approximately 30 years ago and was implemented as a pilot project in the Minuteman missile program. Success in that effort prompted what has become known today in the DoD as the Cost/Schedule Control Systems Criteria (C/SCSC) and in private industry as the Earned Value Management System (EVMS). The C/SCSC currently consists of 32 management criteria detailed in the DoD's acquisi-

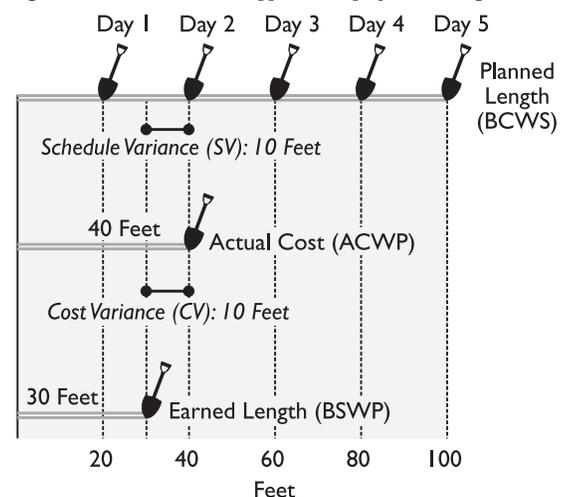
tion policy document *DoD Instruction 5000.2R*. Refer to [7] for an excellent treatment of the management control factors that originally made up the C/SCSC.

Before earned value, the traditional approach to cost and funding management was based on a project expenditure plan. This plan identified a specific funding expense rate over the duration of the project. As progress on the project was made, the total cost expended on the project to date was compared to the planned funding rate. This comparison enabled management to determine whether expenditures were ahead of or behind the amount planned for the project at that time.

The current approach of earned value adds a third dimension to this process: A quantitative estimate is made of the *value* of the work performed. This estimate represents a measure of “what you got for what you paid.” Comparing the earned value to the planned cost for a given period identifies whether the project is ahead of or behind schedule, also called schedule variance (SV). Likewise, comparing the earned value to the costs expended during the period identifies whether the project is underrunning or overrunning its budget, also called cost variance (CV).

Figure 1 illustrates the basic, but often nonintuitive, principles of earned value. Assume you have contracted with an excavator to dig a 100-foot ditch over the next five days. You carefully plan the effort, deciding that total ditch

Figure 1. The earned-value approach to project tracking.



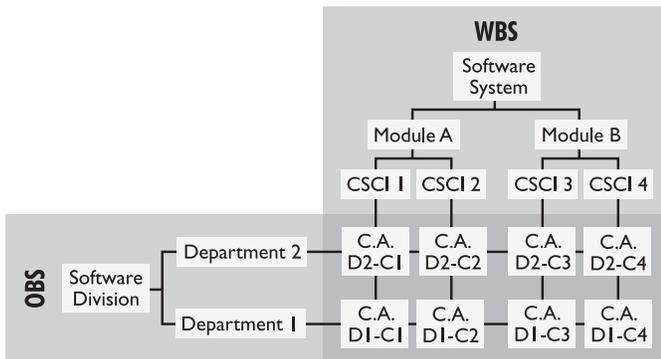


Figure 2. Diagram showing the creation of earned-value cost accounts as the intersection of the organizational breakdown structure and the work breakdown structure.

length dug will be the primary measurement. You scientifically calculate that 20 feet will be dug each day at an agreed hourly wage. The project begins, and after the first day, a 20-foot length of ditch is done. You measure progress and see that according to your plan, you are on schedule and within budget.

The next day is different. Because of unforeseen delays (equipment malfunction, zoning problems, volcanic intrusion, etc.), only 10 more feet are completed. Measuring progress, you find that the “earned value” of your trench is now a total of 30 feet. However, your planned value is 40 feet (two days at 20 feet per day). Furthermore, your actual ditch cost is based on two full days of digging. Therefore, the difference between your earned value of 30 feet and the planned value of 40 feet indicates that after two days, the ditch is 10 feet behind schedule or 10 percent of the planned total ditch length.

Similarly, the difference between the earned value cost of the ditch and the actual ditch cost indicates a potential cost overrun. Additional costs (replacement equipment, zoning fees, explosives, etc.) will simply add to the actual ditch cost, increasing the cost overrun. Assuming no further delays and no acceleration of the digging, 10 more feet of ditch will have to be dug at the end of the five days, adding to the total cost of the ditch.

The measurements of budgeted costs, earned value, and actual costs are generally expressed in dollars or hours. Performance estimates of earned value may be based on lines of code developed, functional units completed, etc., which are then converted to the appropriate units. Earned value provides the cost and expenditure forecast capabilities of traditional cost and funding management but adds the crucial capability of schedule estimation that the traditional approach lacks.

The biggest challenge the earned-value approach has faced has been its association with C/SCSC. C/SCSC has a proven track record as a means to manage and control large projects. From a general perspective, projects for which C/SCSC is both appropriate and usually mandated constitute only 1 percent of all projects [3]. However, the 32 criteria contained

in the current version of C/SCSC are considered cumbersome and likely overkill for the remaining 99 percent.

Still, the principles behind the earned-value approach are both applicable and appropriate for these projects. These principles include proper use of work breakdown structures, cost accounts, performance measurement baselines, selection of appropriate methods to compute earned value, forecasting project performance, and capitalizing upon proven success factors.

The Work Breakdown Structure (WBS) – The use of an appropriate WBS is at the heart of C/SCSC and earned value. All work defined and subsequently tracked by the project can be located within the structure of the WBS. C/SCSC projects usually consist of a two-part WBS. The first two or three levels constitute the *contract work breakdown structure* (CWBS). The CWBS is often defined by the project owner and shows the way that cost and schedule will be monitored and reported throughout the project lifecycle. The project managers and technical team members define the subsequent levels constituting the *project work breakdown structure* (PWBS). At the lowest level of the PWBS, the tasks can be traced directly to project deliverables called out in the project’s technical statement of work. At the lowest levels is the primary tracking mechanism of C/SCSC and earned value: the cost account.

The Cost Account – Cost accounts are created at the intersection of the organizational breakdown structure and the PWBS (see Figure 2). The resulting intersection creates a performance measurement unit that combines the schedule, cost, and technical aspects of the project. C/SCSC defines the cost account as, “A management control point at which actual costs may be accumulated and compared to the budgeted cost of work performed. A cost account is a natural control point for cost and schedule planning and control, because it represents the work assigned to one responsible organizational element on one contract work breakdown structure (CWBS) element.” [8]

Cost accounts provide a correlation between the amount of work that is planned and the resources available to accomplish that work. Each cost account generally contains three pieces of information: the scope of work for the associated WBS element, its schedule, and its budgeted cost.

Performance Measurement Baseline – When the collection of cost accounts are summarized upward, the entire project scope, schedule, and planned cost can be determined. In C/SCSC and earned value, this information is called the “performance measurement baseline” (PMB). C/SCSC defines the PMB as, “The time-phased budget plan against which contract performance is measured. It is formed by the budgets assigned to scheduled cost accounts and the applicable indirect budgets. ... It equals the total allocated budget, less management reserve.” Using the PMB at any time during the performance of the project, the PMB allows the project manager to compare tracking information. Comparing the estimated earned value with the PMB at a given time yields the schedule variance for the project. Similarly, comparing the

Measurement Method	Description	Notes
Weighted Milestone	Useful for short-span tasks. Weighted budget amounts are applied to milestones distributed across the duration of the task. As the milestone is reached, the budget amount is earned.	
Fixed Formula (0/100; 25/75; 50/50)	Useful for detailed short-span tasks. An amount ranging from 0 to 100 percent of the task's budget is earned when the task begins. The remaining percentage is earned when the task is complete.	These measures are typically used to track earned value on non-recurring tasks.
Percent Complete Estimates	Easiest method to administer. A "subjective" estimate of the percentage of work completed is used for the earned value. Requires well-defined work packages and guidelines to determine an accurate percent-complete value.	
Percent Complete and Milestone Gates	Popular method used by government organizations. Uses a combination of weighted milestones and percent complete. "Subjective" percent-complete estimates are allowed up to a specific ceiling associated with each milestone. Advancement past the milestone is not allowed until tangible criteria have been met, hence the term "gate."	
Equivalent Completed Units	Useful for extended duration and repetitive tasks. The overall project is divided into distinct units of accomplishment. Earned value is computed by summing the units completed.	
Earned Standards	Useful for production-type work. Perhaps the most sophisticated method to compute earned value. Standards of performance based on historical cost data, time and motion studies, etc., are used to compute the earned value on a given task. Often, several standards are used simultaneously, and a management consensus determines which standard is ultimately used.	These measures are typically used to track earned value on either nonrecurring or recurring tasks.
Apportioned Relationship to Discrete Work	Useful for tasks in which their performance has a direct relationship to other tasks. The earned value for apportioned tasks is a summary of the earned value measurements made on the work to which it is related. Schedule variances in the apportioned work are usually identical to schedule variances in its related work. However, cost variances in the apportioned work are substantially different from the related work because of the dynamics of actual costs.	This measurement can employ any of the above six methods.
Level of Effort	Generally, level of effort tasks are those that support the overall project. Because these tasks are more time driven than task driven, whatever is set as the planned value is always the earned value, regardless of what work was done.	This method is generally not recommended to track earned value.

Table 1. Different earned-value measures adapted from [3].

earned value with the actual costs posted against the PMB yields the cost variance for the project.

Earned-Value Measurement Methods – With the PMB in place, performance measurements can be made. The specific methods to measure performance and earned value must be selected before the start of the project. A variety of methods to measure earned value have been proposed, and different methods are appropriate for different projects. Patricia W. Hurst presented the "binary reporting" method for earned-value measurement. According to Hurst, binary reporting is useful for projects of which their lowest level WBS work units are relatively small in effort, i.e., four to 80 staff-hours. Binary reporting maintains that work packages are in one of only two states: complete or incomplete. This gives the project manager a specific measure of the progress made with respect to the effort expended [9].

Other methods exist to measure earned value, including methods based on percent complete and weights applied to milestones [3]. Project and cost account managers have the responsibility to determine the most appropriate and effective method. Table 1 lists several categories of these measures.

Forecasting – Perhaps one of the most important benefits of earned value is its ability to forecast the final cost and schedule of a project. Successful forecasting is based on a foundation of a good baseline plan, tracking performance against that plan, and the commitment of upper management to use and act on the performance data. Several methods have been proposed to forecast project performance.

Q.W. Fleming and J.M. Koppelman present a forecast approach based on the work remaining, the cost performance indicator (CPI) and schedule performance indicator (SPI), and the actual costs for the project [3]. In this approach, the cost forecast is determined by computing the remaining work (usually the budget at completion minus the total earned value to date). This factor is then divided by either the CPI or the product of CPI and SPI.

This gives the remaining work with respect to the relative efficiency with which it will be completed. The actual costs expended to date are then added to this amount, yielding the forecasted cost of the project.

The schedule forecast can be determined graphically by examining the earned value and planned costs. Figure 3 displays a line graph in which budget is expressed on the vertical axis, and time is expressed on the horizontal axis. For a given status date, the BCWS, ACWP, and BCWP curves are plotted on the graph. Note that the date corresponds to the point at which the BCWP value intersects the BCWS curve. This date is compared with the status date, yielding the SV. This variance can be applied to critical path information to predict the potential completion date for the project.

Earned-Value Success Factors – As discussed earlier in summarizing ROI, it may be beneficial to consider a plan or road map to implement earned-value analysis in an organization (also see [11]). The following elements will contribute to such a plan.

- Ensure that the project is described by an appropriately detailed WBS with individual work packages at the lowest level.
- Create cost accounts for the project by ensuring that a specific organizational unit has responsibility for each work package.
- Establish a PMB, which incorporates schedule and budget information and against which progress will be measured.
- Identify the method that will be used to compute earned value.
- Identify reporting periods that are appropriate to the project, and identify the earned-value method selected.
- As each reporting period is achieved, measure values for BCWS, BCWP (the earned value), and ACWP. Use these values to compute other indicators, including the CV, SV, CPI, SPI, and other indicators of interest.
- Use the indicators to track and manage the schedule.

DoD and Industry Implementation Examples

ROI and earned value have been implemented with varying results in countless organizations over the past three decades. The following examples illustrate how ROI and earned value are being implemented in the real world.

In 1991, a software technology strategy for the DoD was drafted with three national objectives of note. The objectives included reducing lifecycle costs, reducing software problem rates, and increasing mission capability and interoperability. Over a period of five years, nearly 800,000 source lines of code were inspected. Using the number of major and minor defects identified and the total time to prepare for and inspect the documentation, an estimated ROI of a 4.48-to-1 ratio was computed [5].

Recently, the International Data Corporation conducted several in-depth economic analyses at major corporations. The corporations were inserting new technology to implement software process improvement. In computing ROI, the corporations emphasized four issues: rapid deployment on

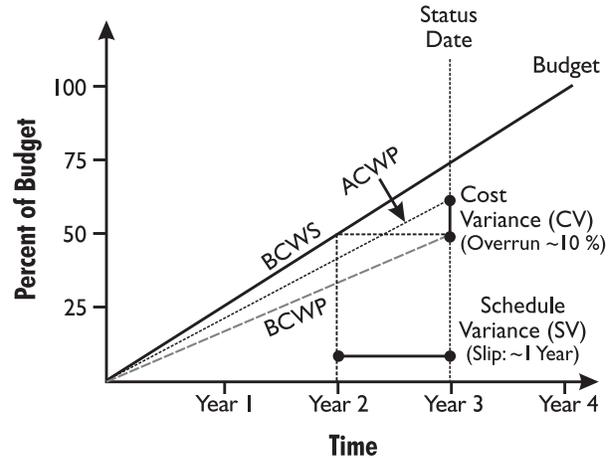


Figure 3. Illustration of the earned-value curves BCWS, BCWP, and ACWP. Representative cost and schedule variances are shown with respect to a given status date. Adapted from [3].

heterogeneous platforms, browser-based interfaces, ease of use, and leveraging openness and its impact on maintenance.

The projects were significant in size, ranging from \$1.4 million to \$4.2 million. A standard definition of ROI was used: ROI equals the amount above a dollar that was returned for every dollar spent in the implementation of the project. Two of the companies were Silicon Graphics and Amdahl. Over a three-year period, Silicon Graphics showed an ROI of 1,427 percent with a payback period of 0.18 years. Amdahl computed their ROI over three years to be 2,063 percent with a payback period of 0.13 years [10].

In 1993, the privately funded, multibillion-dollar IRI-DIUM[®] satellite program began. Because the program was not federally funded, no government requirement was levied for the project to comply with the C/SCSC standard. However, the management group for the project implemented a tailored earned-value approach to manage the project. The earned-value approach was based on a product-type WBS. Earned value was embedded within the project's scheduling activities. Employees were rewarded based on the project's earned-value performance, which included cost and schedule performance and managing the critical path against key milestones. Therefore, this project created a unique approach to establish earned value as a valid and visible management tool.

Summary

ROI and earned value are relatively complex terms with enormous potential to enhance success at improvement activities or any other project. Both have been implemented, but neither consistently nor accurately, in the DoD and private industry. However, significant cost savings are available if their underlying principles are administered properly.

Earned value is related to ROI and is primarily based upon tangible estimates. It is an augmentation of traditional cost and funding management that provides the schedule management aspect that the traditional approach lacks. Earned value is a measure of "what you got for what you

paid” and is based on a foundation of work breakdown structures, cost accounts, performance measurement baselines, mathematical value computation, and schedule and cost forecasting. Any given method to compute earned value could be appropriate for some projects and inappropriate for others, so thought and planning are needed to select the best approach.

ROI is more difficult to uniformly measure and use in a practical manner than earned value. ROI can be computed by summing earned-value measures consistently and combining them with the less tangible estimates. Mathematically, ROI is the ratio of total savings achieved from an improvement effort to the total cost incurred to implement the effort. Some ROI estimates are easy to quantify, particularly those related to specific monetary expenditures and earnings; however, the definition of *costs* and *savings* could be expanded into multiple intangibles, which are much more difficult to estimate. Likewise, multiple methods to compute ROI may exist for each project and for each organization.

Ultimately, organizations that use earned value and ROI as a consistent strategy also will base their business tactics upon strong project management principles. The case for ROI measures can benefit from further study, including methods to compute ROI and identify intangibles and how to address them. ♦

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