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contemporary issues

Earned Value Management: Uses and Misuses

This edition's Contemporary Logistics feature was written by Dr Stephen Hays Russell. Over the years, Dr Russell has been a frequent contributor to the Journal. He is an accomplished logistician and is on the faculty of the John B. Goddard School of Business and Economics, Weber State University. In "Earned Value Management: Uses and Misuses," Dr Russell examines the relevance of Earned Value Management (EVM) to the logistics community. He makes the case that its relevance is threefold. First, today's logisticians are intimately involved in the weapon system acquisition process. Because EVM is such an integral part of the imposed acquisition management architecture, logisticians need to understand the tool. Otherwise, they become tangential to the management and performance reviews of an acquisition program. Second, EVM is increasingly being addressed in the literature of performance based logistics and acquisition logistics. Third, EVM as a leading-edge management tool has not seen the application to logistics-specific projects that it merits.

He concludes with the following points:

- A basic understanding of EVM is important to the logistician, not only because of its intrinsic value to the management of any complex project, but because it is now widely employed in the procurement-program management community of which logistics is a part.
- EVM is able to provide a true picture of a project's cost performance by accounting for differences between work accomplished and work scheduled. A number of metrics are employed for variance calculations, performance indices, and projections at completion.
- Originally developed as a financial management tool, EVM has become a project management tool for cost, schedule, and scope management. However, this broader approach to EVM generates potential for misuse when the schedule metrics of EVM are used to the exclusion of true schedule management tools. In addition, estimate at completion calculations with EVM metrics should be employed judiciously lest misleading projections arise given the circumstances of any particular project.

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Introduction

Earned Value Management was originally developed by the United States Air Force as a financial management tool. Over the years, the earned value technique has matured into a significant project management tool with particular application to the acquisition of weapon systems.

The relevance of EVM to the logistics community is threefold. First, today's logisticians are intimately involved in the weapon systems acquisition process. Because EVM is such an integral part of the imposed acquisition management architecture, logisticians need to understand the tool. Otherwise, they become tangential to the management and performance reviews of an acquisition program. Second, EVM is increasingly being addressed in the literature of performance based logistics (PBL) and acquisition logistics.[1] Third, EVM as a leading-edge management tool has not seen the application to logistics-specific projects that it merits.[2]

Many logisticians have low familiarity with this important management tool. This article examines the conceptual underpinnings of the EVM methodology and its applicability to measuring a project's performance, with particular emphasis on its uses and misuses.

Background of EVM

The earned value concept was developed to correct serious distortions in assessing a project's cost performance generated by comparing actual costs with a time-phased budget. Consider Figure 1, which plots both a time-phased budget (the spend plan) and cumulative actual expenditures to date. Note that at Time_{Now}, actual expenditures are below budget. Cost performance *appears* favorable.

The problem, of course, is this approach fails to consider what work has been done. The cumulative budget at Time_{Now} may contemplate the completion of more tasks than have actually been accomplished. If this is the case, the favorable cost variance could be illusionary.

A more accurate assessment—one that ties budget to tasks actually completed—is possible with the time-phased program plan illustrated in Table 1. Here four tasks have been scheduled to date for a total Time_{Now} budget of $152K. Actual expenditures to date are $128K. However, only Tasks A, B, and C have been accomplished. Hence, comparing the $128K actually spent to the $152K spend plan does not make sense. Why? Because this

Article Acronyms

ACWP – Actual Cost of Work Performed
BAC – Budget at Completion
BCWP – Budgeted Cost of Work Performed
BCWS – Budgeted Cost of Work Scheduled
CAP – Control Account Plan
CPI – Cost Performance Index
CV – Cost Variance
DoD – Department of Defense
EAC – Estimate at Completion
EVM – Earned Value Management
PBL – Performance Based Logistics
SPI – Schedule Performance Index
SV – Schedule Variance

program is behind schedule. Task D has not been accomplished as of $Time_{Now}$. The *earned value* to date—earned in the sense that the tasks have been performed—is $120K. Clearly, we should compare expenditures to date to the earned value. With this comparison, we correctly determine that this project is $8K over budget ($128K spent less $120K budgeted for the tasks actually completed), whereas the spend plan approach suggested by Figure 1 would erroneously conclude this program is under budget by $24K ($152K - $128K). This earned value concept is at the heart of EVM.

The following discussion illustrates that EVM brings together the scope, budget, and cost dimensions of a project and generates metrics for planning, measurement, and control.

EVM Techniques

Earned Value Management requires four pieces of information:

- A baseline plan that defines the project in total
- The tasks planned to be accomplished at $Time_{Now}$
- The budgeted value of the tasks accomplished by $Time_{Now}$
- Actual costs at $Time_{Now}$

The baseline plan is the entire project defined by objectives, tasks, and budget. The aggregated budget for all tasks is called the budget at completion (BAC) and represents the approved funds or the budget constraint for the entire project.

The sum of all tasks in the baseline plan you planned to have accomplished at $Time_{Now}$ in budgeted dollars is called the budgeted cost of work scheduled (BCWS) in EVM terminology. BCWS is the planned value. In Table 1 this value is $152K.

Task	Budget	Status	Actual
A	$40K	Done	$42K
B	$60K	Done	$60K
C	$20K	Done	$26K
D	$32K	Pending	
Total at $Time_{Now}$	$152K		$128K

Table 1. Tasks Scheduled Through $Time_{now}$

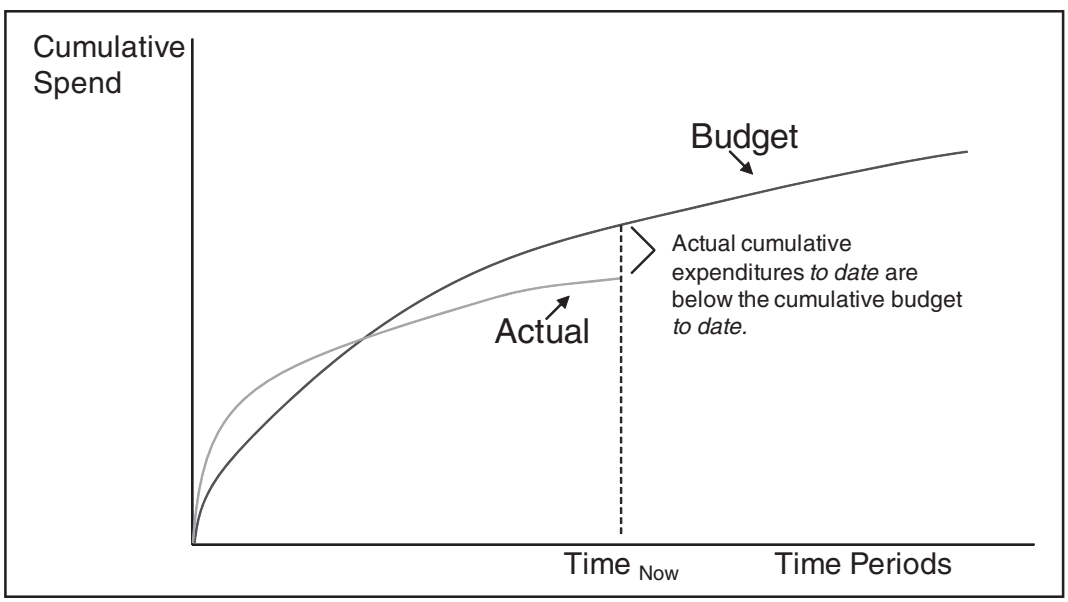

Figure 1. The Spend Plan Approach

The budgeted value of the tasks actually completed at $Time_{Now}$ is the earned value to date and is called the budgeted cost of work performed (BCWP). In Table 1 this value is $120K.

How much you have actually spent to date is called actual cost of work performed (ACWP). In Table 1 this value is $128K.

As suggested earlier, the key piece of information in EVM and the basis for the EVM technique is the earned value, which is BCWP. In all EVM analysis, BCWP is a benchmark number for variance and performance measures.

The Metrics of Performance Measurement

The difference between BCWP and ACWP (that is, the difference between the budgeted cost through $Time_{Now}$ and the actual cost at $Time_{Now}$ for the work performed) is the cost variance (CV). In the Table 1 example, CV is -$8K ($120K - $128K).

The difference between BCWP and BCWS (that is, the difference between the work you have performed and the work you have scheduled through $Time_{Now}$ on a budgeted basis) is schedule variance (SV). In Table 1, SV is $-32K ($120K - $152K).

These performance measurements are expressed formally as:

1. CV = BCWP - ACWP
2. SV = BCWP - BCWS

Note that in both CV and SV calculations the benchmark for measurement is the *earned value*—that is, the BCWP. For these variance measures, positive values portray the project as doing better than planned. Specifically, if for work performed, *actual cost* is less than *budgeted cost*, CV is positive—meaning actuals are less than budget, a favorable condition. For SV, if on a budgeted basis *work performed* is greater than *work scheduled*, a positive value means the project is ahead of schedule. Similarly, negative values portray unfavorable conditions.

Consider Figure 2. BCWP or earned value (the work actually performed on a budgeted basis) is ahead of BCWS (the work scheduled on a budgeted basis) at $Time_{Now}$. This project is ahead of schedule. However, for the work performed, actual cost at $Time_{Now}$ (ACWP) exceeds the budgeted cost (BCWP). This project is experiencing a cost overrun. Indeed, in this example, actual cost will soon reach the BAC constraint—the cumulative BCWS for the whole project. Clearly, action is required by the program manager.

Performance can also be expressed in terms of ratios. The ratio of BCWP to ACWP is the cost performance index (CPI):

3. CPI = BCWP/ACWP

The ratio of BCWP to BCWS is the schedule performance index (SPI).

4. SPI = BCWP/BCWS

For these ratio measures, values greater than 1.0 mean performance is favorable (better than the plan).

Implementing EVM

EVM can be successfully employed in varying degrees of formality and in projects of all sizes. Examples of potential logistics applications of EVM include a complex logistics research project, development and implementation of new software, design and construction of a new maintenance facility, or any other complex project whose plan consists of discrete, time-phased tasks.

Implementation requires the establishment of detailed processes to collect baseline data and to reliably measure performance and cost. For Department of Defense (DoD)-compliant systems (that is, for EVM systems of private sector firms to qualify for defense contracts), the implementation must satisfy 32 official structural and measurement criteria jointly developed by the federal government and industry.[3]

The first step in implementation is identifying the total scope of work that defines the project and creating a master schedule and a budget for project accomplishment. This step defines the scope baseline in tasks, time, and dollars. The scope baseline is the time-phased BCWS, the project's planned value. The project's total budget (the BAC) is the BCWS for the whole project.

Next, the baseline is broken down into miniature project plans called control account plans (CAPs) (see Figure 3). Each CAP will have a programmed start and completion date, an assigned hour and dollar budget, and assigned resources including a manager accountable for accomplishment.

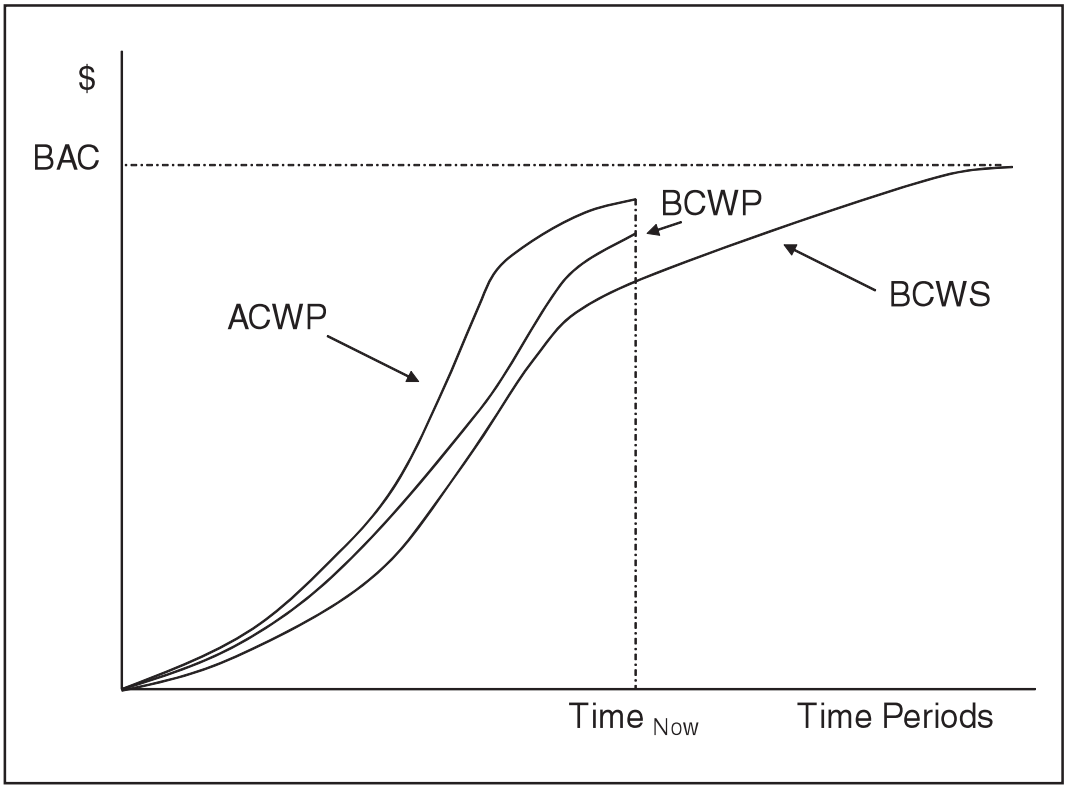

Figure 2. Illustration of EVM Metrics

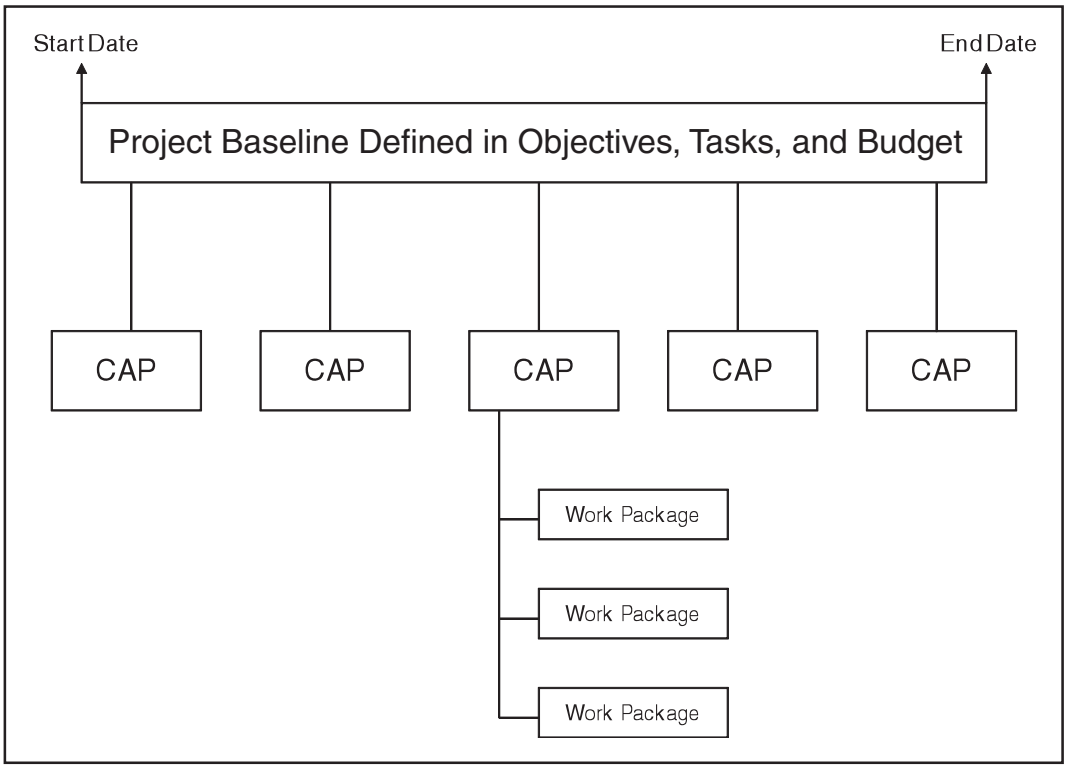

Figure 3. Data and Measurement Structure for Implementing EVM

CAPs are, in turn, disaggregated into discrete work packages. It is at the work package level where earned value is measured and reported at the CAP and ultimately the project level.

The work package level is the genesis for a bottom-up approach to program performance in terms of BCWS, BCWP, and ACWP. Once the project has begun, performance measurement and variance analysis is launched at the work package level and rolled up into the CAP and total program level.

Uses and Misuses of EVM

To illustrate the uses and potential misuses of EVM, consider the metrics portrayed in Figure 4. At Time_{Now}, ACWP exceeds BCWP. The distance CV represents cost overrun to date.

Figure 4 also shows BCWP below BCWS. On a dollarized basis, this program is behind schedule by the amount of SV.

The time dimension of the behind-schedule condition (labeled *Time Variance* in Figure 4) is illustrated by the horizontal distance between BCWS and BCWP. At $Time_{Now}$, the dollar value of work performed (BCWP) should have been achieved at the time period indicated by that same value on the BCWS line.

These performance measures serve the following purposes:

- They can serve as an early warning to the program manager that this program is in trouble. In the Figure 4 example, both variance measures are negative, meaning this program is both behind schedule and over on cost.
- Managers can *drill down* to CAPs and work packages in the EVM database to identify areas and root causes of schedule slippage and cost overruns.
- Constructive actions can be taken as EVM metrics indicate deviations from plan. Actions may include correcting inefficiencies that caused the deviations, the recognition that initial budgets were inadequate for the scope of work programmed, or the application of additional resources to bring the project back on schedule. Conversely, unfavorable schedule and cost performance at $Time_{Now}$ may force the program manager to take tasks out of the project (bring the scope of the total project down) in order to complete the program within a firm BAC.
- Program status at completion can be projected. The CPI can be employed to develop a revised estimate on cost to complete the program. Note from equation 3 the CPI is the ratio of BCWP to ACWP. Assume this value is .90. This means that for every dollar spent, only 90 percent of the programmed work for that dollar is actually getting accomplished. If we assume the CPI to date is indicative of future performance (that is, that the CPI will remain reasonably stable for the duration of the project), then we can use the following equation for an estimate at completion (EAC) calculation:

5. EAC = BAC/CPI

In logic, this equation reduces to the simple proposition that if actual costs are running 11.1 percent ahead of budget for work to date (1.0 divided by .90), a reasonable EAC will likely be 11.1 percent greater than the BAC.

With regard to schedule performance, the SPI given in equation 4 divides BCWP by BCWS. Assume this value is .85. For every dollar of budget (BCWS) only 85 cents worth of work gets completed (BCWP). The inverse of the SPI (BCWS/BCWP) in this example (1.176) would indicate this project is running 17.6 percent behind schedule or that the project is forecasted to take 17.6 percent longer than the original schedule.

These illustrations represent the common employment of EVM to assess the cost and schedule performance of a project. However, rote employment of these metrics is risky and can represent a misuse of EVM—misuse in the sense that these metrics must not be employed in a vacuum or to the exclusion of other performance indicators.

First, consider cost performance metrics. The EAC of equation 5 assumes the remaining work will have the same relative cost variance as work already done.[4] Analysis of root causes or of specific CAPS may show that past performance is not a good predictor of future performance—that a particular problem will not occur again.[5]

Furthermore, if the project is behind schedule, project duration increases and so will costs. Efforts to get the project back on schedule usually mean the employment of more resources (overtime, for example). In short, to project costs without incorporating the cost implications of a schedule variance is a misuse of EVM metrics as well.[6]

The most significant misuse of EVM, however, is in the area of schedule assessment. Using SV as the only measure of schedule performance can lead to erroneous conclusions. For example, some tasks may be performed out of sequence. High-dollar activities may be done ahead of schedule while lesser value critical activities are hopelessly behind schedule. Yet, EVM will show a favorable SV at the project level. A project in aggregate may be ahead of schedule, yet one critical component may not be available. In this situation, heads-up managers know delivery schedules will slip, yet EVM will show this program ahead of schedule.[7]

A quirk of EVM is the fact that every project (even a project behind schedule) shows an SV metric of zero at project completion. This happens because as the project approaches 100 percent completion, the work performed (BCWP) converges on the work scheduled (BCWS)—no more variance. Obviously, at some point prior, the SV as a performance metric has lost its management value.

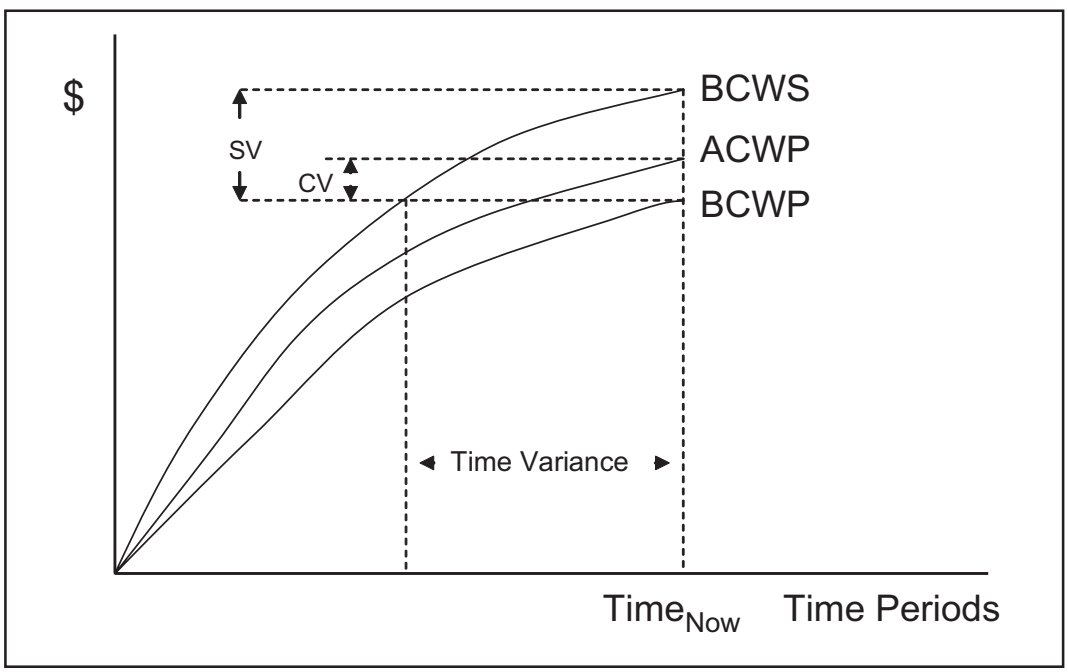

Figure 4. Performance Assessment with EVM Metrics

Clearly, program managers need a schedule management system that is sequence- and milestone-based. EVM may be an aggregate indicator of work performed compared to work scheduled, but to engage EVM as a reliable schedule indicator is a misuse of the tool.[8]

Conclusion

Over the years, a number of significant management innovations and tools with broad application have emerged from the DoD. These include incentive contracting, Performance Evaluation and Review Technique (PERT), configuration management, integrated logistics support, life-cycle costing, and many others. One major tool developed by DoD that continues to face limited familiarity within the logistics community is EVM.

A basic understanding of EVM is important to the logistician, not only because of its intrinsic value to the management of any complex project, but because it is now widely employed in the procurement-program management community of which logistics is a part.

EVM is able to provide a true picture of a project's cost performance by accounting for differences between work accomplished and work scheduled. A number of metrics are employed for variance calculations, performance indices, and projections at completion.

Originally developed as a financial management tool, EVM has become a project management tool for cost, schedule, and scope management. However, this broader approach to EVM generates potential for misuse when the schedule metrics of EVM are used to the exclusion of true schedule management tools. In addition, EAC calculations with EVM metrics should be employed judiciously lest misleading projections arise given the circumstances of any particular project.

This article equips the logistician with an understanding of the terminology and technique of EVM, and provides an appreciation for its uses and potential misuses.

Notes

1. EVM is now an integral part of DoD's guidelines on PBL. See *Performance Based Logistics: A Program Manager's Product Support Guide*, Defense Acquisition University, March 2005, [Online] Available: http://www.dau.mil/pubs/misc/PBL_Guide.pdf, accessed 28 April 2008.
2. The best opportunities for [EVM] 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. Quentin W. Fleming and Joel M. Koppelman, "Earned Value Project Management: A Powerful Tool for Software Projects," *Crosstalk: The Journal of Defense Software Engineering*, July 1998, 23, [Online] Available: http://www.stsc.hill.af.mil/crosstalk/1998/07/value.asp, accessed 11 November 2007.
3. The 32 standards have evolved into an American National Standards Institute (ANSI) standard on *Earned Value Management System Guidelines*, ANSI/EIA-748-A-1998 (R2002). Copies can be ordered from Global Engineering Documents (800-854-7179). DoD policy and guidance on EVM are online and available at www.acq.osd.mil/pm.
4. For a complete assessment of this issue, see David Christensen and Kirk Payne, "Cost Performance Index Stability—Fact or Fiction?" *Journal of Parametrics,* 10 April 1992, 27-40, and David S. Christensen, "Using Performance Indices to Evaluate the Estimate at Completion," *Journal of Cost Analysis and Management*, Spring 1994, 17-24.
5. Different shops, different work forces, different subcontractors, and different cost problems within a project don't necessarily invite a mirrored projection of past performance into the future. And cost variances in production don't necessarily mean similar variances in assembly.
6. Jan Evensmo and Jan Terje Karlsen, "Reviewing the Assumptions Behind Performance Indexes," *Transactions of AACE International CSC 14*, 2004, 1-7.
7. See Jim W. Short, Using Schedule Variance as the Only Measure of Schedule Performance, *Cost Engineering*, Vol 35, No 10, October 1993, 35. Also see Walter H. Lipke, "Schedule is Different," *The Measurable News*, Summer 2003, 31-34.
8. Seasoned practitioners of EVM are increasingly realizing that EVM is considerably more useful as a tool for measuring and managing cost performance than it is for schedule performance. Indeed, the earned value concept was developed to get appropriate data for cost assessment. The dollarized schedule assessment is a byproduct fraught with difficulties. In this sense, EVM better serves project managers as a *financial management* tool rather than a cost-schedule-scope *project management* tool.

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If I had to sum up in a word what makes a good manager, I'd say decisiveness. You can use the fanciest computers to gather the numbers, but in the end you have to set a timetable and act.

—Lido Anthony (Lee) Iacocca

If opportunity doesn't knock, build a door.

—Milton Berle

No form of transportation ever really dies out. Every new form is an addition to, and not a substitution for, an old form of transportation.

—Air Marshal Viscount Hugh M. Trenchard, RAF