SOFTWARE ACQUISITION GOLD PRACTICE
TRACK EARNED VALUE

FOCUS AREA: COST – Project Management

DESCRIPTION OF THE PRACTICE:

SUMMARY DESCRIPTION

Earned value project management involves planning work to a manageable level of detail such that it is feasible to allocate a portion of the budget to each planned work unit (work package), and then tracking progress by the accumulated “value” of completed work units. As work is performed, it is “earned” on the same basis as it was planned, in dollars or other quantifiable units. As the work units are completed, the project earns the budgeted value associated with those work units. This method associates a dollar value with work completed so that it can be compared with the actual spending (to determine cost variance – potential cost overruns), and the planned spending (to determine schedule variance – potential schedule slippage). In this manner, planned and actual spending are integrated with actual work performed. The integration provides greater visibility into the real project status for all stakeholders and thus creates a scenario for better management of risks, for early determination of whether a project is in trouble, and for estimating what will be needed to complete it.

Although tracking earned value occurs during project execution, it cannot be accomplished if appropriate project planning and budget allocation has not occurred up front. The figure below depicts, at a high level, the activities that are necessary in order to effectively implement the principles of earned value management.
**DETAILED DESCRIPTION**

Earned value (EV) management is an integrated system of project management and control that enables a Contractor and their customer to monitor the progress of a project in terms of integrated cost, schedule, and technical performance measures. The Contractor/developer owns the process but the Acquirer/customer has full and timely visibility of the information contained within it. This represents a recent migration in focus from acquirers using EV for inspection and oversight to developers using EV for project management. Traditional project management practice tends to compare actual costs with planned expenditures, and confuses actual costs with actual progress. **EVM provides a third reference point that is an objective view of the status of the effort, i.e., the value to the end goal of the work completed to date.**

Although tracking earned value occurs during project execution, it cannot be accomplished if appropriate project planning and budget allocation has not occurred up front. The figure below depicts, at a high level, the activities that are necessary in order to effectively implement the principles of earned value management.

**DEFINE THE WORK**: The Project Manager must decompose the project into distinct discrete manageable tasks or groups of tasks (work packages) with decisive outputs and specific measurable entry and exit criteria. Each work package has a short duration, or can be divided into a series of milestones whose status can be objectively measured. Each work package can be assigned a start and finish date, a budget value, and can be integrated with higher-level schedules. This activity is often referred to as developing the Work Breakdown Structure (WBS). **It is important to balance the level of detail in the WBS with the needs of the project, with the ultimate goal being the ability to realistically estimate the cost of accomplishing each task** (earned value). Providing too much detail creates an overload of data, creating a tracking nightmare, and stifling the creativity of developers; lack of detail may mask vital information. Guidelines on EVM from the UK Ministry of Defense suggest that 3-4 levels in the WBS are sufficient for most projects, but complex projects (such as building a ship) may require five or six levels.
**SCHEDULE AND BUDGET**: Once the effort is identified through the WBS, the project manager must prepare a budget and schedule for accomplishing the work. This is in contrast to “backing into a schedule” based on an arbitrary fixed dollar amount. Details of budgeting and scheduling are beyond the scope of this document, but essentially involve identifying what resources are needed and how much effort will be required in what time frame to complete each of the tasks in the WBS. What is critical to being able to track earned value is that a portion of the budget is allocated for each work package that comprises the WBS and that the WBS adequately defines all work necessary to meet the agreed-upon requirements for the project.

**MEASURE PERFORMANCE**: This activity focuses on performance, not just planned vs. actual spending. It involves tracking a number of measures starting very early in the project, and analyzing the data to determine real project status. Important measures are:

**Primary Measures**

- **Budget Cost of Work Scheduled (BCWS) – the spending plan**: the dollars (or hours) planned for the effort. The cumulative planned expenditures would equal the total dollars budgeted for the effort for the specified time period. With EVM, the spending plan serves as a performance baseline for making predictions about cost and schedule variance and estimates of completion.

- **Actual Cost of Work Performed (ACWP) – actual spending**: the cumulative actual expenditures on the effort viewed at regular intervals within the project duration.

- **Budgeted Cost of Work Performed (BCWP) – earned value, the measure of technical accomplishment**: the cumulative budgeted value (dollars or hours) of work actually completed. It may be calculated as the sum of the values budgeted for the work packages actually completed, or calculated as the percent work complete multiplied by the planned cost of the project.

**Derived/Calculated Measures**

From the three primary measures it is possible to derive measures that can be used to accurately assess the status of the project and predict its future state.

- **Cost Variance (CV) – The numerical difference between the earned value (BCWP) and the actual cost (ACWP)**. CV = BCWP – ACWP. (Another way of thinking of this is the difference between the planned and actual costs of work completed.)

- **Schedule Variance (SV) - An indicator of how much a program is ahead of or behind schedule. SV = BCWP – BCWS**. (Another way of thinking of this: earned value – planned budget, or the difference between the value of work accomplished for a given period and the value of the work planned). Schedule variance is presented well in chart format.

- **Cost Performance Index (CPI) – The cost efficiency factor representing the relationship between the actual cost expended and the earned value**. CPI = BCWP/ACWP. A CPI ≥ 1 suggests a relatively efficient cost factor, while a CPI <1 may be cause for concern.

- **Schedule Performance Index (SPI) – The planned schedule efficiency factor representing the relationship between the earned value and the initial planned schedule**. SPI = BCWP/BCWS. A SPI ≥ 1 is good. SPI < 1 suggests actual work is falling behind the planned schedule.

- **Budget at Completion (BAC) – sum total of the time-phased budget. Synonymous with “Performance Measurement Baseline”**.

- **Estimate to Complete (ETC) – A calculated value, in dollars or hours, that represents the cost of work required to complete remaining project tasks**. ETC = BAC – BCWP.
- **Estimate at Complete (EAC)** – A calculated value, in dollars or hours, that represents the projected total final costs of work when completed. \( \text{EAC} = \text{ACWP} + \text{ETC} \).

In looking at the list of important measures, **earned value (BCWP)** is one of the three basic measures from which the other measures are derived. Without it, the other measures are not possible.

Earned value credit should be binary, with 0 percent being given before task completion and 100 percent given when completion of each work unit is validated. Establishing specific measurable exit criteria for each task makes it easier to track task completion, and thus credit the earned value of the task to the project so that the earned value of the project at any given point in time is obtained by “simple math” rather than by subjective assessment.

**COMMUNICATE PERFORMANCE STATUS**: Tracking earned value is of little value if the estimating and analysis capability that it provides is not used to manage the project. Although originally required for reporting project status to the acquirer, in recent years there has been a migration of focus. EVM is now viewed as a project management technique, as well. Its usefulness is broader than simply reporting project status up the management chain. There are some important reasons to communicate the project status (represented in terms of earned value) to all stakeholders.

- **Promote Accountability** - When developers understand how their individual work (or lack thereof) influences the project, they tend to be more focused on their specific work goals. They also better understand the significance of estimating the amount of work needed to complete specific tasks. There exists a mindset among some project managers that they should “protect” their developers from the distraction of project metrics. In reality, communicating project status to the development staff tends to establish a sense of accountability for their assigned pieces of the project and often results in more realistic estimates for completion of future tasks.

- Reporting real project status, including earned value, at regular intervals provides an opportunity to **address potential problems early** in the project when it is still possible to resolve problems and avoid cost overruns and schedule slippage. The project team takes a proactive approach to **prevent problems from occurring**. Management uses the information to **resolve issues that are beyond the control of the project team**. The time interval should be at least monthly, regardless of the size and duration of a project, and more frequent for some projects. Many practitioners experienced with earned value management indicate that the project team should review project earned value weekly, because it can alert the team to specific problem areas before they develop into major problems.

**Illustrative Example:**
Here are some examples of how tracking earned value improves the accuracy of communicating real project status.

Assuming a project budget of $300K (with $100K allocated for the first four months), planned to be implemented over 12 reporting periods (1st 4 periods shown here), a sufficiently detailed WBS, and an accurate method of crediting earned value, Table 1 provides the primary project level data that would be captured under principles of EVM to communicate project status. Data typically captured (and measures reported) under a traditional approach are shaded blue in both tables. Rows shaded gold represent additional data collected and measures reported using an EVM approach.
Table 1: Primary Measures of Earned Value Management

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Planned</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Actual Costs</td>
<td>22</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>92</td>
</tr>
<tr>
<td>Earned Value</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>

Under the traditional project-reporting paradigm (Planned vs. Actual spending), at the end of 4 periods this data shows that the project is underrun by $8K. However, when "tracking earned value" is added as an additional reference point, the data shows that the project is overrun by $12K (see Cost Variance in Table 2). This is the effect of integrating EV into the project monitoring process. It focuses on reporting progress from the perspective of work completed, and that focus brings a whole new dimension to the status of a project. In this case, the difference in project status ($20K), as reported by the two approaches, amounts to 20% of the funding ($100K). Table 2 illustrates other metrics derived from earned value data that can be used, not only to better assess the current status of the project, but also to make more realistic predictions about where the project is headed.

Table 2: Derived Measures of Project Status

<table>
<thead>
<tr>
<th></th>
<th>$3K</th>
<th>$8K</th>
<th>$8K</th>
<th>$8K</th>
<th>$8K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Variance (CV)</td>
<td>-$2K</td>
<td>-$2K</td>
<td>-$7K</td>
<td>-$12K</td>
<td>-$12K</td>
</tr>
<tr>
<td>Cum EV – Cum Actual Cost</td>
<td>-$5K</td>
<td>-$10K</td>
<td>-$15K</td>
<td>-$20K</td>
<td>-$20K</td>
</tr>
<tr>
<td>Schedule Variance (SV)</td>
<td>20/25 ≈ 0.80</td>
<td>40/50 ≈ 0.80</td>
<td>60/75 ≈ 0.80</td>
<td>80/100 ≈ 0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>Cost Performance Index (CPI)</td>
<td>20/22 ≈ 0.91</td>
<td>40/42 ≈ 0.95</td>
<td>60/67 ≈ 0.90</td>
<td>80/92 ≈ 0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>Estimate to Complete (ETC)</td>
<td>300 – 20 = $280K</td>
<td>300 – 40 = $260K</td>
<td>300 – 60 = $240K</td>
<td>300 – 80 = $220K</td>
<td>$20K</td>
</tr>
<tr>
<td>Estimate at Complete (EAC)</td>
<td>22 + 280 = $302K</td>
<td>42 + 260 = $302K</td>
<td>67 + 240 = $307K</td>
<td>92 + 20 = $312K</td>
<td>$312K</td>
</tr>
</tbody>
</table>

Communicating earned value does not make problems go away automatically, but it can provide objective consistent measures that are useful in focusing attention on the “real” status of the project, as follows:

- Cost and schedule efficiency factors <1 are cause for concern
- Downward trend in CPI is consistent with government findings in monitoring projects since the 1970s (see below)
- Even with fluctuation, data reported early in the project is a good predictor of what will happen later
- Frequent reporting of EV data supports trend analysis that can better communicate the direction of the project
The DoD has been able to make several determinations about projects in general by using data collected from projects where tracking earned value was required (over 400 projects since 1977).

- **Without exception, the cumulative CPI does not significantly improve between the period of 15% and 85% of contract performance period. In fact, it tends to decline.** For example, a CPI of 0.75, derived from data at the 15% mark suggests that if the budget and schedule remain constant, only 75% of the work will be completed at project end. This clearly indicates early in the project a need to adjust budget, schedule, and/or the scope of work.

- **Studies show that EACs based on both the CPI and the SPI tend to be significantly higher and are generally more accurate** ([Christensen, 1996](#)).

By adding the 3rd primary measure, earned value, to project reporting we provide the opportunity to uncover, address, and resolve problems early. The Figure below (EVM Workshop) presents a typical project status report used with EV. In graphical form, it quickly communicates cost variance and schedule status in addition to the technical completion status of the project relative to the baseline.
CHARACTERISTICS OF IMPLEMENTATION:

SUMMARY CHARACTERISTICS

NO DATA CURRENTLY AVAILABLE

ANTICIPATED BENEFITS OF IMPLEMENTATION:

Successful implementation of the Earned Value Management principles can result in:

• **Better Visibility into Program Performance**
  The combination of advance planning, baseline maintenance, and earned value analysis yields earlier and better visibility into program performance than is provided by non-integrated methods of planning and control.

• **Reduced Cycle Time to Deliver a Product**
  Earned value management is premised on careful detailed planning – task decomposition, scheduling, and budgeting. This planning often addresses/prevents problems from surfacing later in the effort that result in rework. Thus, as rework is prevented cycle time may, in fact, be reduced.

• **Fosters Accountability**
  When the developer, at the personal level, understands how their pieces fit into the overall project effort they tend to focus on delivery of a quality product. Additionally, over time they are better able to estimate the work required to complete a task, thereby improving the overall accuracy of the budget/estimating process for future efforts.

• **Reduced Risk**
  Because earned value measures enable realistic estimates of completion (for both cost and schedule) to be derived early in the project, it is possible to make adjustments and take corrective action to mitigate the risk of cost overruns and schedule slippage.
# Detailed Characteristics

## Key Characteristics of the Track Earned Value Gold Practice

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Practice on Large DoD Software Intensive Systems</strong></td>
<td>• Required on DoD projects &gt;$40M. See DoD Instruction 5000.2-R.</td>
</tr>
<tr>
<td><strong>Requires a Disciplined Approach to Project Planning</strong></td>
<td>• Formalized planning and reporting processes must be established as part of the project management infrastructure.</td>
</tr>
<tr>
<td><strong>Integrates Cost, Schedule and Performance Metrics</strong></td>
<td>• Work completed is represented as a dollar value portion of the budget, and compared with planned and actual expenditures to measure progress and communicate project status.</td>
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<tr>
<td></td>
<td>• Removes the myth that actual costs equate to actual technical progress.</td>
</tr>
<tr>
<td><strong>Decompose Project Tasks to “Inch-Pebbles”</strong></td>
<td>• A work breakdown structure is a necessary part of project planning. Task decomposition must be performed with granularity sufficient to enable accurate estimation of cost and resources for task completion.</td>
</tr>
<tr>
<td><strong>Allocate Budget at the Detailed Task Level</strong></td>
<td>• A portion of the spending plan (budget) is allocated to each specific task</td>
</tr>
<tr>
<td><strong>Report Project Status at Frequent Regular Intervals</strong></td>
<td>• At least monthly – more frequently on short projects</td>
</tr>
</tbody>
</table>
| **Involve Development Team in Developing Task Estimates** | • Realistic estimates are critical to making EV a useful, meaningful practice  
  • Developers improve their estimating ability over time  
  • Other factors in the organizational culture can impact the credibility of developer estimates. Teams built on trust and mutual respect are more successful at estimating. |
| **Track Task Completion at the Detail Level**             | • Use binary status – done or not done – on detailed tasks and activities within the project to aid in determining work unit completion                                                                       |
| **Credit Earned Value Only on Full Completion of Task**   | • Binary quality gates – done or not done – no partial credit  
  • Apply earned value credits at the detailed task level (inch-pebbles)                                                                                                                                     |
| **Communicate Project Status to Developers as Well as Customers** | • EV principles are used to manage projects, not just report project status  
  • Individual developers take on ownership for their efforts when the focus of the project is outcome-based                                                                                     |
| **Not a “Silver Bullet” for Already Failing Projects**    | • If a project is more than 50% expended and in trouble, implementing EVM at that point does not guarantee success, although it may provide sufficient insight about the project status to enable discussions about the best course of action  
  • EVM is a prevention-based approach to project management                                                                                                                                             |
| **Applicable to Most Projects with a Duration of Longer Than a Few Months** | • In general, the larger/longer the project, the greater the need for implementing EVM, and the greater its value for project management                                                                        |
| **Necessitates Educating Project Team on EVMS**           | • Developers need to understand how it works, what it is used for, and how it contributes to a successful project  
  • Managers need to “practice what they preach” regarding use of EV data                                                                                                                                   |
| **Based on Mutual Integrity and Trust**                   | • Establishing arbitrary budgets will degrade the integrity of earned value data  
  • Developers must be trained to estimate, and then trusted. If their estimates are not used, they will stop providing true estimates                                                                                 |
RELATIONSHIPS TO OTHER PRACTICES:

The Figure below represents a high-level process architecture for the subject practice, depicting relationships among this practice and the nature of the influences on the practice (describing how other practices might relate to this practice). These relationship statements are based on definitions of specific “best practices” found in the literature and the notion that the successful implementation of practices may “influence” (or are influenced by) the ability to successfully implement other practices. A brief description of these influences is included in the table below.

<table>
<thead>
<tr>
<th>Inputs to the Practice</th>
<th>Facilitate Establishing and Tracking Earned Value Metrics</th>
<th>Management involvement and support is critical</th>
<th>Support/encourage use of earned value metrics</th>
<th>Provide objective data for determining earned value credits</th>
<th>Alert PMs to potential schedule and cost risks early</th>
<th>Provide quantitative data for decision-making</th>
<th>Communicate project status</th>
</tr>
</thead>
<tbody>
<tr>
<td>The significance of “earned value tracking” is based on the notion that the Project Manager is able to accurately estimate the resources (and therefore cost) necessary to complete each task in order to allocate a portion of the budget to it (earned value). The following practices may help the project manager (and the team) to do the planning that is necessary to provide accurate earned value estimates that are ultimately used to track progress on the project:</td>
<td>Establish Clear Goals and Decision Points</td>
<td>Performance-Based Specifications</td>
<td>Goal-Question-Metric Approach</td>
<td>Binary Quality Gates at the Inch Pebble Level</td>
<td>Provide a documented project performance trail for use</td>
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<tr>
<td>The DoD acquisition process has undergone a paradigm shift with regard to tracking earned value, from a reactive project monitoring role (as evidenced by the requirements to use CSSR, or Cost Schedule Status Report) to a proactive project management role that supercedes CSSR with a requirement for contractors to comply with the industry standard earned value management system. This allows contractors to use their own systems and provides more flexibility for internal management than the previously rigid requirements of the CSSR. Earned value is now perceived as a management tool as well as a reporting tool.</td>
<td>Support/Encourage Use of Earned Value Metrics</td>
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</tbody>
</table>
Management Involvement and Support Is Critical

Tracking earned value cannot work unless managers have the planning skills, the appropriate work ethic, and the tools to facilitate maintaining project data. Management must be accountable for their planning and for providing the estimates that are used to establish earned value. They must have the proper training, and they must establish and maintain good working relationships with the team—an environment in which truth and trust prevail. They must implement a disciplined process for estimating work and tracking it through completion. Implementing configuration management of the project data is essential for managing and communicating the metrics relating to earned value as the project progresses.

Provide Objective Data for Determining Earned Value Credits

A task’s earned value cannot be credited until the task is complete. The Project Manager must determine up front (during planning) what constitutes completion of a task. There may be several criteria that must be met. No partial credit is given. Formal inspections and demonstration-based reviews provide an objective basis for determining task completion, thus facilitating crediting earned value. This is in contrast to completion status based on subjective assessment of the developer, for example saying, “I just have a little bit more to do on it—so it’s essentially done”—but it really isn’t done.

OUTPUTS FROM THE PRACTICE

Alert PMs to Potential Schedule and Cost Risks Early

Measures derived from tracking earned value can be used to establish thresholds that automatically trigger alerts to situations that are then addressed through formal risk management. This is viable in the early stages of the project (near 15% completion). This is probably the most significant benefit of tracking earned value.

Provide a Documented Project Performance Trail for Use

Since tracking earned value integrates planning (budgeting), actual spending, and actual technical accomplishment, project data that encompasses earned value tracking provides a comprehensive historical performance trail that can be used internally for planning future projects, for improving the task estimating process (and therefore the acquisition process), and for determining which contractors have the best record for delivery of quality products, on time, and within budget thus providing data to support best value awards.

Provide Quantitative Data for Decision Making

Tracking earned value quantifies project completion status by providing a means for viewing actual accomplishment in terms of planned value (dollars or hours) and integrating it with other quantitative measures such as budget, and actual costs, thereby facilitating more meaningful analysis of schedule, effort, and costs. The subjectivity exists only during the initial estimation required to establish the earned value for a task. Thereafter, the measures are quantitative, including the binary completion status of each task. The resulting project data can be used to improve the task estimation process for future efforts as well.

Communicate Project Status

Integrating earned value within the typical project progress charts that compare actual spending to planned spending provides another important dimension for better communicating project status. It enables accurate predictions of the real cost to complete a project (and the real schedule) to be made early in the project so that adjustments can be made before a crisis situation develops.

Using earned value to communicate progress provides the overall picture and should be part of any scheduled project reviews. There is a tendency for project reviews to include demonstrations of accomplishments in lieu of dialog about them. The practice of tracking earned value is not just for reporting to the customer. It should be included in regular internal project team reviews, as well providing all stakeholders with visibility of progress vs. plan.
RESOURCES:

**Websites**

- Management-Technologies, Inc. has developed an Earned Value Maturity Model [http://www.mgmt-technologies.com/evmtech.html](http://www.mgmt-technologies.com/evmtech.html)
- Earned Value Management (EVM) website (sponsored by OSD) [http://www.acq.osd.mil/pm/](http://www.acq.osd.mil/pm/)
- NASA Earned Value Management (EVM) Website: The mission of this site is to provide a primary on-line reference point for EVM theory, application, and use as an integrated project management tool within NASA. [http://evm.nasa.gov/](http://evm.nasa.gov/)
- Ministry of Defense, United Kingdom – Acquisition Management Website [http://www.ams.mod.uk/ams/content/docs/evm2/evmacq2.htm](http://www.ams.mod.uk/ams/content/docs/evm2/evmacq2.htm)

**Tools and Methods**

State-of-the-art methods and tools that may be useful in implementing and improving the effectiveness of earned value management include:

- Team Software Process
- Personal Software Process
- Earned Value Management Maturity Model
- Project Management Tools that aid in establishing and tracking EV

This site, part of DAU's Acquisition community Connection (ACC), provides links to material on software tools for earned value management. [http://pmcop.dau.mil/simplify/ev.php?ID=52966_201&ID2=DO_TOPIC](http://pmcop.dau.mil/simplify/ev.php?ID=52966_201&ID2=DO_TOPIC)


**Experts/Contact Points**

- Paul Solomon, Northrop Grumman Corp. (Paul.Solomon@pb-ev.com)
- Quentin W. Fleming, Primavera Systems, Inc. (QuentinF@Primavera.com)

**Training Opportunities:**

- Tecolote Research, Inc. is a privately held firm that is nationally known for providing integrated financial management services, including earned value training, for clients within the U.S. Government [http://www.tecolote.com/Services/EarnedValue.htm](http://www.tecolote.com/Services/EarnedValue.htm)
• Humphreys & Associates, Inc. is a management consulting firm specializing in Earned Value Project Management since 1978 with both on-line and conventional courses customized for both public and private sector organizations
http://www.humphreys-assoc.com/on-line/courses/courses.html
http://www.humphreys-assoc.com/workshops/workshops.html

• Management Technologies provides two courses in EVM
http://www.mgmt-technologies.com/seminars.html

• VitalThought is a Project Management company that specializes in the Earned Value technique of project management as defined by the DoD Cost Schedule Control System Criteria
http://www.vitalthought.com/Training/training.html

• Quentin W. Fleming Project Management Consultancy provides a one-day seminar covering all fundamentals necessary to implement projects that employ the earned value project management concept
http://www.quentinf.com/#Project%20Management

• Program Management Associates, Inc. (PMA) is an SBA-qualified small business, incorporated in 1988, dedicated to project management support and training
http://www.pma-inc.com/earned.htm

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[DODD 5000.2] DoD 5000.2-R, “Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs”, 5 April 2002


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(Replaces DoD 5000.2-R, canceled 30 October 2002)


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http://www.spmn.com/products_guidebooks.html

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DEFINITIONS:

Earned Value Management (EVM) is an integrated system of project management and control that enables a contractor and their customer to monitor the progress of a project in terms of integrated cost, schedule, and technical performance measures.

- [Acquisition Management Website, Ministry of Defense, UK]

Earned value is a management technique that relates resource planning to schedules and to technical cost and schedule requirements. All work is planned, budgeted, and scheduled in time-phased "planned value" increments constituting a cost and schedule measurement baseline. There are two major objectives of an earned value system: to encourage contractors to use effective internal cost and schedule management control systems; and to permit the customer to be able to rely on timely data produced by those systems for determining product-oriented contract status.

- Earned Value Management Website
**SOURCES (Origins of the Practice):**

The concept of earned value originated with industrial engineers in factory settings in the early 1900s. They assessed their cost performance by comparing the physical factory work output (earned value) against the actual costs incurred, and then to the physical work planned. They defined *cost variance* as the difference between the actual costs and the earned value. This definition is critical to implementing the earned value concept.

- **DoD Financial Management Orders, since 1967**
  Although expressed with different terminology the basic principles of earned value management have been recommended for use in the DoD since the early 1960s when it issued a directive that imposed 35 *Cost/Schedule Control Systems Criteria (C/SCSC)* on all private and industrial firms that wished to participate in future major systems procurements. That directive focused on *oversight and inspection* and caused EV to be viewed only as a reporting tool.

  In 1996, and as a result of participation by private industry, the DoD endorsed a replacement of the C/SCSC, which became known as the industry standard “Earned Value Management System” (EVMS) and reduced the number of formal criteria to 32. The standard, identified as EIA-748, has since been updated and is now available (for a fee) from the ANSI Standards body.
RECOMMENDING SOURCES:

- **USD (A&T), August 1999**
  In August of 1999, Dr. Jack Gansler, USD (A&T), signed a memorandum announcing that the DoD had adopted the **ANSI Earned Value Management System (EVMS) Standard** for use on defense acquisitions. The standard incorporates best business practices that have proven to provide strong benefits for program and enterprise planning and control. It is available electronically for a fee (Doc # EIA-748) from Global Engineering Documents.


- **Interim Defense Acquisition Guidebook, 30 October 2002 [INTERIM 2002]**
  [This document now supercedes DoD 5000.2-R.]

C2.9.3.4 INTEGRATED CONTRACT PERFORMANCE MANAGEMENT. The four paragraphs within section C2.9.3.4 provide detail on the contract situations in which the ANSI EVMS guidelines and the Cost/Schedule Status Report (C/SSR) DID DI-MGMT-81467 (DoD 5010.12-L) must be followed.

C2.9.3.4.1 The PM shall obtain integrated cost and schedule performance data to monitor program execution. The PM shall require contractors to use internal management control systems that produce data that a) indicate work progress; b) properly relate cost, schedule, and technical accomplishment; c) are valid, timely and able to be audited; and d) provide DoD PMs with information at a practical level of summarization. Unless waived by the Milestone Decision Authority (MDA), the PM shall require that contractors’ management information systems used in planning and controlling contract performance meet the EVMS Guidelines set forth in the ANSI/EIA-748-98 document.

AP4 APPENDIX 4 EVMS GUIDELINES, MANDATORY PROCEDURES, & REPORTING. This appendix reproduces the guidelines contained in the ANSI/EIA-748-98 document.

- **Capability Maturity Model Integration (CMMI), Version 1.1 Staged, Software Engineering Institute, CMU/SEI-2002-TR-012, TR-012, March 2002**

  Three key process areas (KPAs) specifically address tracking work performance and comparing it to scheduled or planned activity, although they do not specifically require the use of the earned value measure.

  **PG 97 Project Planning KPA, SP1.1.** Establish a top-level work breakdown structure (WBS) to estimate the scope of the project. In the list of sub-practices the following text appears:

  The top-level WBS is intended to help in gauging the project work effort in terms of tasks and organizational roles and responsibilities. The amount of detail in the WBS at this more detailed level helps in developing realistic schedules, thereby minimizing the need for management reserve.

  **PG 101 SP 1.4** Estimate the project effort and cost for the work products and tasks based on estimation rationale.
SP 2.1. Establish and maintain the project’s budget and schedule.

Project Monitoring and Control KPA. SG 1 Monitor Project Against Plan. Actual performance and progress of the project are monitored against the project plan. The sub-practices include the following:

Monitor progress against the schedule. Progress monitoring typically includes:
- Periodically measuring the actual completion of activities and milestones
- Comparing actual completion of activities and milestones against the schedule documented in the project plan
- Identifying significant deviations from the schedule estimates in the project plan

Monitor the project’s cost and expended effort. Effort and cost monitoring typically includes:
- Periodically measuring the actual effort and cost expended and staff assigned
- Comparing actual effort, costs, staffing, and training to the estimates and budgets documented in the project plan
- Identifying significant deviations from the budgets in the project plan.

Measurement & Analysis KPA. The purpose of M&A is to develop and sustain a measurement capability that is used to support management information needs.

The integration of measurement and analysis activities into the processes of the project supports the following:
- Objective planning and estimating
- Tracking actual performance against established plans and objectives
- Identifying and resolving process-related issues
- Providing a basis for incorporating measurement into additional processes in the future

SP 1.2 Specify Measures. Measurement objectives are refined into precise quantifiable measures. ... Earned Value is identified as an example of a commonly used derived measure.
GLOSSARY

**ACWP**
Actual Cost of Work Performed. The actual cost incurred on the project to date, irrespective of what was budgeted.

**Airlie Council**
Refers to a group of experts convened by the Navy’s Software Program Manager’s Network (SPMN) in 1995 who established/identified nine best practices. These practices have been augmented with other practices since 1995, and in current literature are referenced as the original Airlie best practices.

**BAC**
Budget At Completion. The total original budget for the project, representing the total value of work to be performed, synonymous with performance baseline.

**Baseline**
With respect to Earned Value, a baseline is the planned value of project tasks to be completed in a given reporting period, broken out by task.

**BCWP**
Budgeted Cost of Work Performed. Interchangeable with cumulative earned value; a metric representing the planned value for the amount of work completed on the project to date.

**BCWS**
Budgeted Cost of Work Scheduled. The total value of work that was originally scheduled for completion by the end of a reporting period.

**Best Practice**
A documented practice aimed at lowering an identified risk in a system acquisition and is required or recommended by a bona fide DoD, industry, or academic source.

Methodologies and tools that consistently yield productivity and quality results when implemented in a minimum of 10 organizations and 50 software projects, and is asserted by those who use it to have been beneficial in all or most of the projects.

**C/SCSC**
Cost/Schedule Control Systems Criteria

**Cost Variance**
The difference between the earned value and the actual cost of work performed (Cost Variance = BCWP - ACWP). A negative variance means more money was spent for the work accomplished than was planned.

**CSSR**
Cost Schedule Status Report (DI-MGMT-81467)

**EAC**
Estimate at Completion. The current best estimate for the total cost of the project. This value may differ from the BAC over time because better estimates can be made as the project progresses.

**Earned Value Management**
An integrated system of project management and control that enables a Contractor and their customer to jointly monitor the progress of a project in terms of integrated cost, schedule and technical performance measures.

**EV**
Earned Value. A means of evaluating budgetary performance by relating actual expenditures to technical achievement as measured by a milestone accomplishment scheme. EV may be used interchangeably with BCWP.

An objective measurement of how much work has been accomplished on a project.
**Gold Practice**  
A term coined by the DACS to identify a practice that provides intrinsic value to an organization or program that acquires or develops software. The DACS term focuses on the realization that a practice may be “worth its weight in gold” in cost savings and process improvements for specific programs and organizations, irrespective of whether other organizations have successfully or unsuccessfully implemented it, by emphasizing that there are other practices/processes that influence, or are influenced by, the success or failure of the Gold Practice.

**PM**  
Program Manager

**Schedule Variance**  
The difference between the earned value and the planned value of the project at/for a specific reporting period (Schedule Variance = BCWP – BCWS). A negative variance indicates that less work was accomplished than was planned.

**SPMN**  
Software Program Managers Network
CASE STUDIES FROM THE LITERATURE:

Practical Software Measurement: Performance-Based Earned Value
Successful software project management can be achieved by focusing on requirements, selecting the most effective software metrics, and using Earned Value Management. Best practices and lessons learned by the Northrop Grumman team in developing weapons system software for the B-2 Stealth Bomber are discussed.
http://www.testablerrequirements.com/Articles/solomon.htm

EVM and Software Project Management – Our Story
The Software Division at Tinker Air Force Base in Oklahoma has used earned value management (EVM) methods for more than 15 years. These management methods have had significant influence in the improvement of software development and maintenance practices of the organization. This article, in a story-telling manner, describes the use of EVM for managing software, and how its system of management facilitated a natural evolution that lead to recognition, awards, and more importantly, on-time, at-cost, quality software.

All the Right Behavior
Software projects using the Team Software ProcessSM (TSP™) have an unusually high rate of on-time completion. One of several key factors contributing to this accomplishment is the effective way TSP teams make use of earned value techniques to iteratively refine their plan as they work it. Because earned value is reviewed weekly, and because no value is earned either at the personal or the team levels until a task is fully completed, software engineers are highly motivated to perform good earned value practices. This article expounds upon this principle and examines how TSP teams succeed with earned value.