JOURNAL OF
Software Technology
July 2011 Vol.14 No.3

Analyzing and Measuring Information Quality

http://journal.thedacs.com

http://iac.dtic.mil/dacs
Unclassified and Unlimited Distribution

Formerly the SoftwareTech news

Improving the Quality of Earned Value Management Information

By Paul Solomon

WHEN FORMAL PROCESSES FAIL TO REPORT THE TRUE PROGRESS AND EFFECTIVENESS OF SYSTEMS AND SOFTWARE DEVELOPMENT EFFORTS, BAD OUTPUT DATA CAN BE MISLEADING TO THE PROGRAM AND COSTLY TO THE STAKEHOLDERS.

Earned Value Management (EVM) is an integrated system of project management and control that is intended to enable Program Managers (PM) and their customers to monitor the progress of a project in terms of integrated cost, schedule, and technical performance measures. 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. But what if the EVM information being provided to the PM is bad?

Today, a supplier is not required to base earned value on technical performance or quality. Technical linkage is optional in the industry standard, ANSI/EIA-748 (EVMS). Per EVMS, EV is based on the quantity of work performed, not quality (EVMS Quality Gap).

The May-June 2011 Defense AT&L article, "Path to EVM Acquisition Reform," includes recommended regulatory changes that would require that EV be linked to quality. The article also cites the National Defense Authorization Act for FY 2011 which addresses this issue.[1]

Real acquisition reform takes years to implement. A PM can act now to obtain accurate EVM information. Guidance is also provided below to strengthen Defense Contract Management Agency's (DCMA's) surveillance support.

Immaculate Misconception

PMs rely on DCMA to assure that the supplier's EVM data is reliable and accurate for decision making purposes. However, even if DCMA reports that the supplier is EVMS-compliant, the EV information is often inaccurate and misleading. This reliance on DCMA's blessing is an immaculate misconception. DCMA uses the National Defense Industrial Association (NDIA) EVMS Intent Guide's definitions and interpretations when verifying supplier compliance. A PM is vulnerable because of the Quality Gaps in Intent Guidelines 7, 14, and 30.

These Guidelines and the associated Gaps are explained in the following sections:

Guideline 7 - Measure Progress

Guideline: Identify physical products, milestones, technical performance goals, ***or*** other indicators that will be used to measure progress.

Gap: Progress may be objectively measured by counting physical products completed (I.E. drawings, software designs or units, lines of code, tests performed, engineering changes, software problem reports) regardless of technical performance achieved. The NDIA Guide's *interpretation* of the guideline states "these measures are necessary to substantiate technical achievement against the schedule plan." However, when I addressed the DCMA EVM Center Conference[2], the participants confirmed that a supplier's failure to base EV on technical achievement or baselined functionality is not evidence of non-compliance with the Guideline.

Examples of compliant practices that enable misconceptions of technical progress follow.

- EV is based on the percent of iterations, drawings, computer software units etc. completed even though the evolving design does not meet planned technical performance or software functionality.
- The same conditions exist, as above, but the supplier arbitrarily caps EV at an arbitrary 95% percent complete until technical completion criteria are met.
- Rework, often called "engineering changes" or software

1 The May article and other articles discussed here are linked at http://pb-ev.com/advanced.aspx.

2 http://pb-ev.com/Documents/DCMA%20Performance%20Based%20EVM%20PDF.pdf

problem reports, is objectively measured. However, the rework indicates the failure to meet requirements. Better measures would indicate progress towards meeting Technical Performance Measures (TPM) planned values or baselined software functionality.
- A software build is released or "turned over" without achieving its baselined functionality. The work package status is set as 100 percent complete based on the release even though it is behind schedule and functionality has been deferred to the next build.

Guideline 14 - Management Reserve (MR)

Guideline: Identify MR and undistributed budget.

Gap: The NDIA Guide's interpretation states that MR is for "for unplanned events that may arise" and because MR "is not yet tied to work, it does not form part of the Performance Measurement Baseline (PMB)." In practice, MR is used to provide additional budget and time for planned tasks in the PMB that failed to meet, or no longer meet, previously planned technical performance.

The following examples illustrate common supplier practices that, in my opinion, result in the use of MR for planned tasks that should have been part of the PMB. These practices also enable MR to be used to mask pending or accumulated overruns. DCMA often finds these practices as compliant based on the NDIA interpretation that the tasks are "unplanned" or "unexpected" work scope growth. Consequently, there are misconceptions about true cost and schedule performance.

- Rework is not included in the PMB. It is identified as a risk and included in MR. Later, budget is transferred from MR to the PMB when the design or test item does not meet, or no longer meets, technical requirements. The Government Accountability Office (GAO) report, GAO-11-677T includes a finding on the Joint Strike Fighter (JSF) program of engineering changes that "exceed those planned at program outset and are not in line with best practices."
- Cost drivers such as software lines of code (LOC), number of drawings, hours per drawing or per LOC, are understated compared with empirical data and realistic estimates. The low ball estimate is called "management challenge" and identified as a risk, not an issue. Later, budget from MR is transferred to the PMB to cover the risk.
- The same conditions exist, as above, but no "risk" was identified. Instead, the additional iterations are called "scope growth" even though the basic tasks were planned in the PMB. GAO-11-677T included a finding that the JSF program underestimated the time and effort needed to develop and integrate software.
- The number of tests (and resultant rework and problem reports) is understated based on realistic estimates and empirical data. Later, the tests and rework needed to meet technical requirements are budgeted from MR as "additional scope" even though the customer requirements are stable.
- Work that could not be completed internally is transferred to a supplier. MR is used under the pretext that it is "additional scope" or "unplanned."

Guideline 30 - Retroactive Changes

Guideline: Control retroactive changes to records pertaining to work performed that would change previously reported amounts for actual costs, earned value, or budgets. Adjustments should be made only for correction of errors, routine accounting adjustments, effects of customer or management directed changes, or to improve the baseline integrity and accuracy of performance measurement data.

Gap: This guideline actually discourages accurate reporting of EV. It prevents negative adjustments to EV despite recent knowledge that the previously reported EV is now overstated. Conditions that justify negative adjustments include rework, improved knowledge of the total statement of work, and better understanding of cumulative technical progress.

The guideline permits correction of errors but the NDIA Guide interprets these to be data entry errors. The guideline provides for adjustments to EV only to improve the baseline integrity and (not or) accuracy of performance measurement data. Both suppliers and DCMA personnel have told me that negative adjustments to cumulative EV are not permitted without a baseline change.

The following examples describe conditions that justify negative adjustments to EV.

- EV is based on the percent complete of the original number of planned iterations, drawings, problem reports etc. When the real number of units grows (bigger denominator), the percent complete should be based on the new denominator and may be less than previously reported.
- Previously completed requirements, drawings, software

modules, or other work products are returned for rework because they no longer meet technical performance requirements and there is no separate work package for rework.

In practice, suppliers often "hold" the reported, cumulative EV when the above conditions become known. However, their hesitancy to actually reduce EV provides inaccurate, misleading status.

PM Actions

PMs can improve the quality of EVM information if they:

- Focus on the technical baseline and technical measures.
- Require effective requirements traceability to the supplier's PMB.
- Use the Integrated Master Plan (IMP) to push technical success criteria and TPM to the Integrated Master Schedule (IMS) and PMB.
- Verify the integration of technical objectives with cost and schedule objectives during the Integrated Baseline Review (IBR) and major technical reviews.
- Use the IMS success criteria to define and control incremental functionality for planned builds.
- Select the most effective measures of technical and software progress.
- Account for deferred functionality.
- Use program systems engineering and software engineering staff to bolster EVM surveillance.
- Independently assess EV based on known technical performance and achieved functionality.
- Monitor supplier's reporting of rework and use of Management Reserve (MR).

Focus on the Technical Baseline and Measures

Design and test work packages should have completion criteria that are derived from the technical baseline, planned functionality, and related TPMs that are approved at the Preliminary Design Review (PDR). The product baseline, as approved at the Critical Design Review (CDR), is the basis for subsequent tests and verification.

During Integrated System Design, the systems engineering activities should be tracked discretely in addition to the design development. These include documentation and approval of Measures of Effectiveness (MOE), Measures of Performance (MOP), TPMs, verification methods, verification criteria and other systems engineering work products. Trade studies are also discretely measured because their completion is necessary to define the requirements or to select a design alternative.

The derivation and flow down of the technical baseline and TPMs are shown in Figure 1.

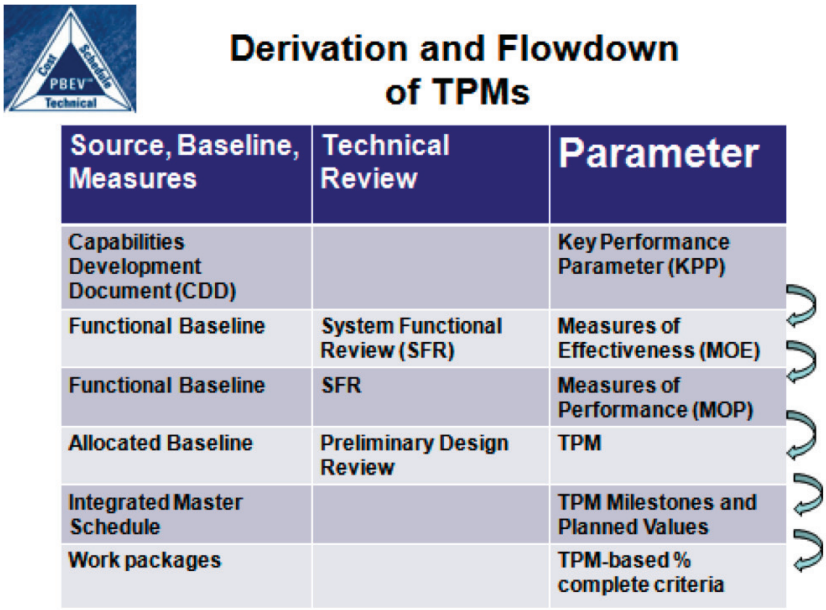


Figure 1: Derivation and Flowdown of TPMs

The product baseline, as approved at the CDR, is the basis for subsequent tests and verification. The relationships of the baselines, technical reviews, and measures through the System Verification Review (SVR) are shown in Figure 2.

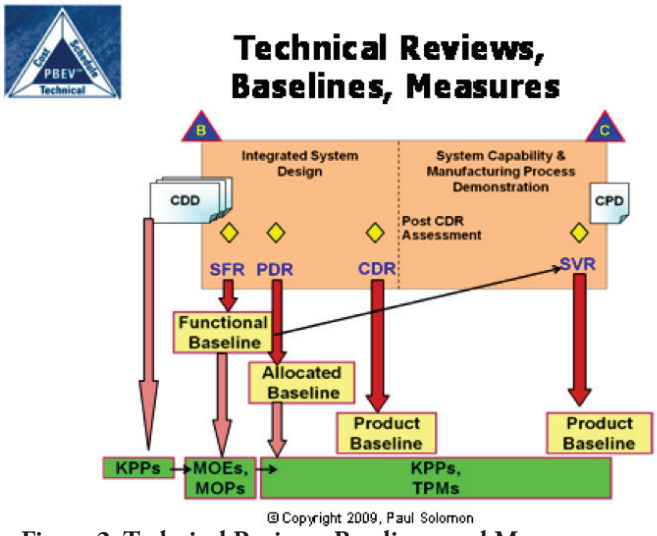


Figure 2: Technical Reviews, Baselines, and Measures

Require Effective Requirements Traceability

An example of using the requirements traceability matrix to develop the PMB for requirements management, traceability, and verification is provided in the CrossTalk magazine article, "Practical Performance-Based EV," May 2006, Example 3.

Use the IMP

EV measurement begins with defining the milestone completion criteria for work and planning packages. The completion criteria should support IMP success criteria. The milestones and completion criteria should include the following:

- **System Functional Review:**
  - All MOPs, MOEs, defined and accepted.
  - Software process IMP/IMS events, schedule, task definitions, and metrics updated to reflect subsystem/allocated functional specification and further defined for the next phase
  - Software requirements traceability defined through the higher tier specifications to the system/subsystem requirements
- **PDR:**
  - All trade studies needed to define MOPs and MOEs are completed.
  - All TPMs defined and accepted.
  - TPM planned values and milestones defined and scheduled.
  - All verification methods and criteria defined and accepted.
  - Specifications of all prototypes, models, and simulations needed developed and accepted.
  - Incremental software development plan defined and scheduled including functional requirements allocation to each block, version, and release and milestone dates.
  - Requirements traceability matrix traceable to IMP criteria, IMS milestones, and work and planning packages.
- **Software Specification Review (SSR):**
  - Software and interface requirements established in internal baselines
  - Requirements allocation for first increment or for all planned increments (blocks/builds) defined (as applicable)
  - Software and interface requirements allocated to Computer Software Configuration Items (CSCIs) and Computer Software Units (CSUs)
  - Software requirements traceability between system/subsystem specifications and software requirements specification refined
  - Software development schedules reflecting contractor selected processes and IMP/IMS events for CSCIs and CSUs refined
  - Software requirements verification matrix established
- **CDR:**
  - For total system, see Software Tech News article, "Agile EV and the Technical Baseline," Sept. 2009, Table 1.
  - For software, see Appendix A of USAF Weapon Systems Software Management Guidebook (AF SW Guide)[3]

Incremental Functionality

Software development is usually planned as a series of versions or builds. Each build includes incremental functionality that is traceable to the requirements baseline and includes the set of supporting requirements. The initial completion milestone for a build includes meeting its TPM criteria.

The AF SW Guide, Section 3.2, provides guidance for requirements and incremental software development. It recommends completing the software and interface requirements specifications and baselining them prior to developing incremental software builds.

Deferred Functionality

Often, a decision is made to close or release a build even though it has not achieved its planned functionality, as defined by the TPM. In that case, the tasks required to meet the remaining requirements are transferred to a subsequent build. If the IMS task and completion milestone are described only in terms of build numbers, not functionality, then the IMS may fail to show that planned functionality has not been achieved. Similarly, if earned value for the build's work package is tied only to the completion of the build, not to the functionality achieved, then earned value may indicate that the work package is completed even though the functionality is behind schedule.

An example of accounting for deferred functionality is provided is provided in the 2010 Department of Defense (DoD) Systems and Software Technology Conference tutorial

3 https://acc.dau.mil/CommunityBrowser.aspx?id=191921&lang=en-US

beginning at slide 102[4].

Measures of Software Progress

Guidance for selecting the best measures of software progress is provided in the Software Tech News article "Applying EVM to Software Intensive Programs," April 2009, with examples in Figure 3.

Independently Assess EV

If suppliers continue to provide EV that is not based on technical performance or achieved functionality, perform independent assessment of EV and substitute your values for supplier values when performing variance analysis and Estimates at Completion.

Systems Engineering, Software Engineering and DCMA Teaming

If the program's system engineering and software engineering personnel team with DCMA EVM surveillance personnel, the PM can obtain more insight into the degree of integration between EV and technical performance. The additional knowledge can be used to strengthen the success criteria for technical reviews and to provide more accurate independent estimates of real vs. reported EV.

DCMA EVM surveillance personnel can also benefit from the program technical support personnel to assess adequacy of work package completion criteria, interim performance measures, measurement of rework, and accounting for deferred functionality. They can also advise when a negative earned value adjustment is justified.

How Commercial IT Companies Get Accurate Information

Commercial Information Technology (IT) companies use EVM to get accurate information without government regulatory requirements. Samsung IT's practices are discussed in the PMI Measurable News article, "Performance-based EV in Commercial IT Projects," 2010 Issue No. 2.

Conclusions

Real acquisition reform can lead to more accurate and reliable EVM information. The PM can take interim

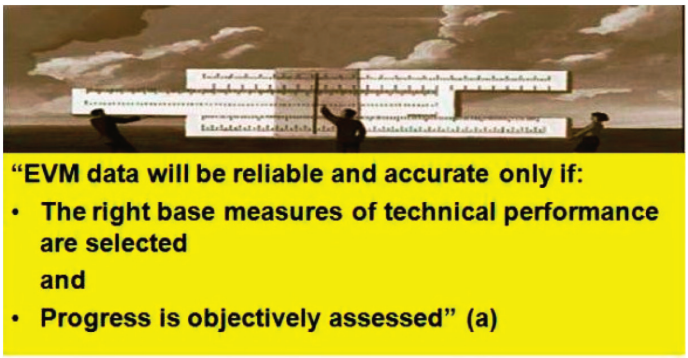
		WHAT TO MEASURE	
			Information Category Measure Mapping*
	Information Category	Measurable Concepts	Prospective Measures
1	Schedule and Progress	Milestone completion	Mileston Dates
		Critical Path Performance	Slack Time
		Work Unit Progress	Requirements Traced, Requirements Tested, Problem Reports Opened, Problem Reports Closed, Reviews Completed, Change Requests Opened, Change Requests Resolved, Units Desgined, Units Coded, Units Integrated, Test Cases Attempted, Test Cases Passed, Action Items Opened, Action Items Completed
		Incremental Capacity	Components Integrated, Functionality Integrated
2	Resources and Cost	Pewrsonnel Effort	Staff Level, Development Effort, Expereince Level, Staff Turnover
		Financial	BCWS, BCWP, ACWP, Budget, Cost
		Environmental/Support	Qualaity Needed, Quality Available, Time Available, Time Used
3	Product Size & Stability	Physical Size/Stability	Database Size, Compomnents, Interfaces, LOC
		Funtional Size	Requirements, Function Changes, Function Points
4	Product Quality	Functional Correctness	Defects, Age of Defects, Technical Performanmce
		Maintaniability	Time to Release, Cyclomatic Complexity
		Efficeincy	Utilization, Throughput, Response Time
		Portability	Stand Comp-Oliance
		Usability	Operator Errors
		Realibility	MTTF
5	Process Performance	Process Cxompliance	Reference Maturity Rating, Process Audit Findings
		Process Efficiency	Productivity, Cycle Time
		Process Effectiveness	Defects Contained, Defects Escaping, Rework Effort, Rework Components
6	Technology Effectiveness	Technology Suitability	Requirements Coverage
		Technology Volatility	Baseline Changes
7	Customer Satisfaction	Customer Feedback	Satisfaction Rating, Award Fee
		Customer Support	Request for Support, Support Time
			* Practical Software Measurement; McGarry, Card, Jones; Addison-Wesley2002

Figure 3: What to Measure

4 http://pb-ev.com/Documents/Integ%20SE%20with%20EVM%20SSTC.pdf

corrective actions to narrow the EVMS Quality Gap and see through the Immaculate Misconception.

About the Author



(a) "Integrating Systems Engineering With Earned Value Management" in *Defense AT&L Magazine*, May 2004

Paul Solomon, PMP, is President of Performance-Based Earned Value® (PBEV) and co-author of the book with that title. He retired from Northrop Grumman Corp. where he was the EVM monitor of the F-35 Joint Strike Fighter, Global Hawk, and B-2 programs. He is co-author of ANSI/EIA-748, the EVMS standard, and received the DoD David Packard Excellence in Acquisition Award. He was a Visiting Scientist at the Software Engineering Institute and published "Using CMMI to Improve EVM." He has also taught PBEV to IT companies in India and S. Korea. His web site contains practical guidance and best practices, www.-pb-ev.com . He holds a BA and an MBA from Dartmouth College and is a certified Project Management Professional.