Integrated Program Management Using EVM – It's Essential! - a Sequel

Paul Solomon May 20, 2019

Abstract

Pat Finneran, in his keynote speech at EVM World 2018, emphasized the difference between measurement/reporting and management; explaining how *integrated program management* (**IPM**) using EVM was essential. This sequel to his speech provides guidance to implement IPM by augmenting an organization's EVM process with Systems Engineering (SE) standards and models and with the Project Management Institute (PMI) *Guide to the Project Management Body of Knowledge* (PMBOK® Guide).

Christle's Vision and Finneran's Message

The goal of IPM is not new. In 1999, Gary Christle, one of the founding fathers of EVM, stated his Vision and presented a Challenge:

- Vision: "The quality of a management system is determined not by the absence of defects, but by the presence of management value."
- Challenge: "Integrate cost, schedule, technical performance, and risk management."[1]

In 2018, Pat Finneran broadened Christle's vision by citing the product and the requirements. He made the following key points in his keynote speech[2]:

- Make the **product the boss**...***Focus on the product, the requirement, and make that the boss.***
- If you don't have good ***requirements flow down*** along the WBS…EVM is going to have gaps.
- Talk about the cost and schedule based on EVM data, ***quality, and technical performance…risks and risk mitigation. It was this structure that was key to success.***

Dept. of Defense (DoD) Focus on SE

SE was first championed in 2004 in the "Policy for SE in DoD." A goal was established "to rejuvenate the SE process and drive good SE back into the way we do business." It makes the case that the "application of rigorous SE discipline is paramount to the Department's ability to meet the challenge of developing and maintaining needed warfighter capability."[3]

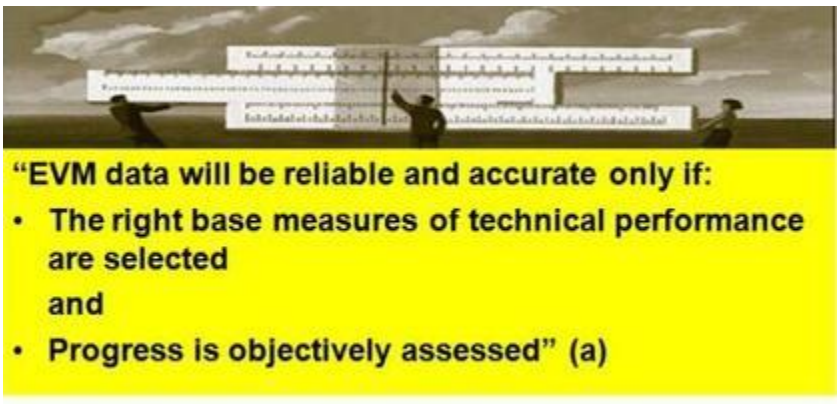
The Weapon Systems Acquisition Reform Act of 2009 (WSARA) was sponsored by Senators John McCain and Carl Levin to force DoD to change its acquisition process and crack down on the runaway costs and costly schedule delays dogging many Pentagon weapons programs. When introducing the legislation, Levin said the key lies in better early planning, SE, cost-estimating, and early developmental testing and McCain said that it is needed to focus acquisition and procurement on emphasizing SE and more effective upfront planning and management of technology risk.[4] WSARA included provisions for EVM as well as SE.

EVM Status in 2009 regarding SE

WSARA required DoD to submit a report to Congress which assessed the use of EVM. The DoD report reiterated Christle's Challenge, which was still unmet, and augmented it with new challenges. One of these was the "Perceptual Challenge" that "EVM Lacks Precise, Quantifiable Measures That Ensure Reliable Reporting of "Value." The report specified that "EVM has no provision to measure the quality of work."

The report included a remedy to that perception with guidance that "The program manager should ensure that the EVM process measures the quality and technical maturity of technical work products instead of just the quantity of work performed." It added "EVM processes be augmented with a rigorous SE process." A breakdown of that guidance, divided between SE and technical performance measurement (TPM), is provided in Table 1.

Table 1 DoD EVM Report Guidance	
TPM	The right things must be measured - and they must be measured the right way – to ensure EVM's success.
	If good TPMs are not used, programs could report 100 percent of earned value…even though they are behind schedule in validating requirements, completing the preliminary design, meeting weight targets, or delivering software releases that meet the requirements.
SE Process and Products	SE and EVM should be integrated and not stove-piped.
	SE products are costed and included in EVM tracking.
	Measures of technical performance (engineering-designated TPMs) are identified and associated with completion of appropriate work packages, enabling progress to be objectively assessed.
	EV completion criteria must be based on technical performance, the quality of work must be verified, and criteria must be defined clearly and unambiguously.
Note: The source of the guidance above was an article in *Defense AT&L Magazine*, "Integrating SE with EVM."[5]	



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

The article cited above concluded that a contractor may be compliant with EVMS but fail to truly integrate measurement of cost, schedule, and technical performance. A program manager should ensure that integrated plans, schedules, and the earned value PMB are linked with the

contract requirements, TPMs, and unambiguous exit criteria. By requiring or encouraging suppliers to adhere to industry standards for systems engineering or engineering processes, EVM will provide more reliable information.

A sequel to that article was published in the *Measurable News* (MN) in 2016, "Integrating SE with EVM, Part 2."[6] The sequel included detailed guidance and recommendations for integrating EVM with risk management (RM) and with the product requirements, as follows**.**

Integrating RM[7]

- Establish RM Milestones on the Baseline Schedule
- Define Exit Criteria for RM Decision Points
- Budget the RM Effort
- Use TPMs as a Basis for RM and EV
- Address RM in Performance Analysis and Exception Reports
- Establish Management Reserve for Risk Reduction
- Consider RM in EAC Development

Integrating Requirements[8]

Leading IT companies in South Korea and India used techniques to link EV with technical performance and the product requirements. Techniques use by Samsung include:

- Defining the requirements baseline for each planned product release
- Tracing the requirements baseline to the schedule and work packages
- Tracking status of each requirement
- Monitoring technical performance with meaningful variance analysis
- Accounting for deferred functionality
- Planning and measuring rework
- Making negative adjustments to EV for accurate status

SE Standards as Framework for IPM

SE standards can provide a framework to integrate EVM into IPM. The Federal government encourages the use of voluntary consensus standards (VCS) such as EIA-748 to achieve the following goals:

- Decrease the cost of goods procured and the burden of complying with agency regulation
- Further the reliance upon private sector expertise to supply the Federal government with cost-efficient goods and services.

SE standards and similar models and guides that support IPM include:

- Processes for Engineering a System (ANSI/EIA-632)
- Standard for Application and Management of the SE Process (ISO/IEC 26702:2007/IEEE 1220)
- SE Leading Indicators Guide, Version 2.0 (Massachusetts Institute of Technology, International Council on Systems Engineering (INCOSE), and Practical Software and Systems Measurement)
- Capability Maturity Model Integration (CMMI) for Development

- CMMI for Acquisition
- INCOSE SE Handbook, A Guide for System Life Cycle Processes and Activities
- CMU/SEI Technical Note, Using CMMI to Improve EVM 9

Key elements of these SE documents are the technical scope (or product baseline), requirements, success criteria, SE tasks and work products, TPMs, and risk mitigation plans

Provisions of the above documents, which address the key elements, are provided in Table 2.

Table 2

Table 2 Key Elements of SE Documents	
ISO/IEC 26702, (6.1, 6.2)	**Work Products** • **Customer expectations** • **Project, enterprise and external constraints** • ***Operational scenarios*** • ***Measures of Effectiveness (MOE)*** • **Interfaces** • ***Functional requirements*** • ***Measures of Performance (MOP)*** • **Modes of operation** • **Design characteristics** • **Documented trade-offs**
ISO/IEC 26702, (6.6): Success Criteria (of Critical Design Review)	**Success Criteria** • **Design solution meets:** – ***Allocated performance requirements*** – ***Functional performance requirements*** – **Interface requirements** – **Workload limitations** – **Constraints** – **Use models and/or prototypes to determine success**
SE Leading Indicators Guide, Leading Indicators	**Requirements Validation Trends** **Insight Provided: Progress against plan in assuring that the customer requirements are valid and properly understood.** **Base Measures:** **1. Requirements** **2. Requirements Validated** **Requirements Verification Trends** **Insight Provided: Progress against plan in verifying that the design meets the specified requirements.** **Base Measures:** **1. Requirements** **2. Requirements Verified** **Technical Measurement Trends** **Insight Provided: Progress towards meeting MOEs) / MOPs/ Key Performance Parameters (KPP)s and TPM** **Base Measures:** **Values of Technical Measure**

CMMI *for Development* **Requirements Development**	**Specific Practice (SP) 3.2** **Establish a Definition of Required Functionality** **Example work products:** • **Functional architecture** • **Activity diagrams and use cases** **Subpractices** **1. Analyze and quantify functionality required by end users** **2. Allocate functional and performance requirements to functions and subfunctions**
CMMI *for Development* **Requirements Development**	**SP 2.2** **Allocate product component requirements** **Example work products:** • **Requirement allocation sheets** • **Design constraints** • **Derived requirements** **Subpractices** **1. Allocate requirements to functions** **2. Allocate requirements to product components**
CMMI *for Development* **Risk Management**	**Goal 3: Mitigate Risks** **Specific Practice 3.2 Implement Risk Mitigation Plans** **Monitor the status of each risk periodically and implement the risk mitigation plan.** **Informative Components:** **Subpractices:** **4. Establish a schedule or period of performance for each risk handling activity that includes the start date and anticipated completion date.** **5. Provide continued commitment of resources for each plan to allow successful execution of the risk-handling strategy.** **6. Collect performance measures on the risk-handling activities.**
CMMI for Acquisition	**Goal 3 Supplier technical solutions are evaluated to confirm that contractual requirements continue to be met.** **SP 1.1 Select Technical Solutions for Analysis** **3. Identify the functional and quality attribute requirements to be satisfied by each selected technical solution.** • **A traceability matrix is a useful tool for identifying requirements for each selected technical solution** • **Includes information that relates requirements to work products**

Provisions of the Technical Note, which specify CMMI work products, are provided in Table 3.

Table 3: CMMI Work Products	
Process Area	**Work Products**
Requirements Development	**Prioritized customer requirements**

	Customer constraints on the conduct of verification **Customer constraints on the conduct of validation** ***Activity diagrams and use cases*** **Derived requirements** **Relationships among derived requirements** ***Product requirements*** **Definition of *required functionality* and *quality attributes*** ***TPMs***
Requirements Management	***Requirements traceability matrix (RTM)***
Verification	***Verification methods* for each selected work product** ***Verification criteria*** ***Exit and entry criteria for work products*** **Verification results**
Measurement and Analysis	***Measurement objectives*** ***Specifications of base and derived measures***

TPMs in the "INCOSE SE Handbook" are specified in Table 4.

Table 4 TPMs in INCOSE SE Handbook
4.3.1.4: The architectural design baseline ...includes: • **TPM Needs – TPMs are measures tracked to influence the system design** • **TPM Data – Data provided to measure TPMs** **5.1.2.2 Systems Engineering Plan (SEP)** • **TPMs are a tool used for project control** • **The extent to which TPMs will be employed should be defined in the SEP.** **5.7.2.4 TPMs** • **Without TPMs, a project manager could fall into the trap of relying on cost and schedule status alone** • **This can lead to a product developed on schedule and with cost that does *not meet* all *key requirements*.** • **Values are established to provide limits that give early indications if a TPM is out of tolerance.**

Failure to Address the Challenges

The Challenges posed by Christle, augmented in the DoD Report, and amplified by Finneran remain unmet. So what? Contractors may continue to report EVM data that is not based on technical performance because they have no contractual requirement to do so. DoD has not implemented any acquisition reforms in defense acquisition regulations or other contractual reporting requirements, such as Data Item Descriptions, to ensure that the EVM process measures the quality and technical maturity of technical work products or to require EVM processes are augmented with a rigorous SE process.

In recent years, some legislators spoke out and acted.

Sen. McCain delivered the following remarks on the Senate floor regarding the continuing need for defense acquisition reform:

"We are once again reminded of the DoD's chronic inability to rein in costs associated with its largest and most expensive weapon and IT systems…what is all-important is getting activity ''under contract,'' ''keeping the money flowing,'' and maintaining budgets…the prime contractor allowed to maximize profit without necessarily delivering needed capability to our service men and women on budget or on time."[10]

Senator Joni Ernst, when sponsoring a potential remedy, the Program Management Improvement and Accountability Act of 2015 (PMIAA), expressed her legislative intent as "This bipartisan legislation puts our federal government back on track by streamlining efforts and outlining strategies to correct widespread deficiencies, lax oversight and unnecessary cost overruns incurred by preventable delays in meeting stated program goals and deadlines."[11]

EIA-748 has several limitations that impede meeting DoD's Perceptual Challenge and Mr. Finneran's key points.

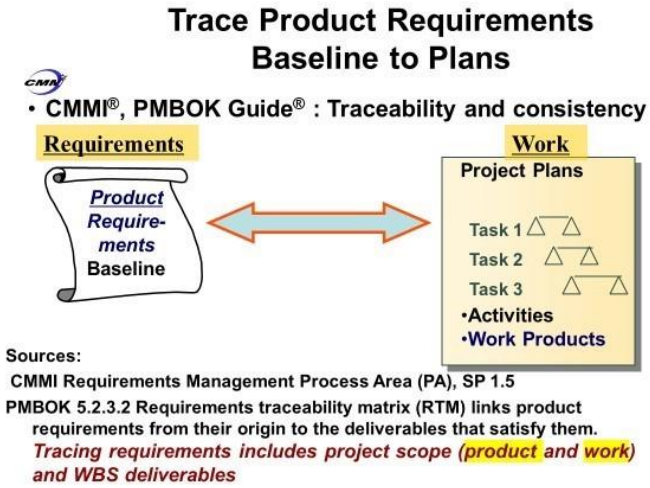
Product Scope vs. Work Scope

EVMS addresses only work requirements, not product requirements. Although EVMS discusses the use of a work breakdown structure to segregate work scope requirements into definable product elements (section 3.2) and discusses preventing revisions to the budget except for authorized changes (section 2.5.d), it does not discuss the work, plans, budgets, or schedules in relation to the product requirements.[12]

Requirements Flow Down vs. WBS Breakdown

EIA-748 prescribes the extension of the "Work" Breakdown Structure (WBS) to control accounts but is silent on the flow down of the product requirements to the WBS and to work packages. Both CMMI and PMBOK® Guide provide guidance to trace product requirements to project plans, including work products, as illustrated in Figure 1.

Figure 1



Quality vs. Quantity of Work

Guideline 7 focuses on the quantity of work but not the quality (Quality Gap). The intent of Guideline 7 specifically excludes quality, as follows:

- The purpose for identifying objective indicators is to provide a means to measure the ***quantity of work accomplished*** – the earned value.
- Performance measures are one aspect of an IPM system as ***other processes control the quality and technical content of the work performed.***[13]

Federally-mandated Panel Cites EVM Limitations

The National Defense Authorization Act for Fiscal Year 2016, Section 809, directed DoD to establish an advisory panel (Panel) with a view toward streamlining and improving the efficiency and effectiveness of the defense acquisition process and to make recommendations for the amendment or repeal of regulations. In 2018, that Panel addressed the Quality Gap by stating that "another substantial shortcoming of *EVM* is that it *does not measure product quality.* A program could perform ahead of schedule and under cost according to EVM metrics but deliver a capability that is unusable by the customer…Traditional measurement using EVM provides *less value* to a program than an Agile process in which the end user continuously *verifies that the **product** meets the **requirement**.*"[14]

Risk Mitigation

The Risk Management process area (of CMMI) relates to several other process areas including the Project Monitoring and Control process area. EVMS is silent on risk management. Risk management is inferred, but not explicitly stated, in the discussion of management reserve. The discussion states management reserve is held for growth within the currently authorized work scope, rate changes, and other program unknowns (EVMS, Section 3.5.4). However, EVMS provides no information regarding the identification, analysis, or mitigation of risks.[15]

Contrary and Supporting Evidence and Opinion

The need to make the elements of IPM a government regulatory requirement or to incorporate IPM into EIA-748 has not been universally accepted.

In 2010, Wayne Abba and Neil Albert stated that there is no need to mandate the integration of TPMs with EVM, as follows.

"The requirement to measure technical performance as intended is not universally understood or followed as well as it should be. When a manager takes credit for earned value whether technical performance has been achieved or not, it makes the project appear to be achieving better performance than it actually is. Better establishment of effective entrance and exit criteria to ensure earned value metrics are objective is an obvious remedy that can be reinforced within the existing National Defense Industrial Association (NDIA) guidance and by contractors and government oversight agencies… Do we need Congress to mandate the integration of TPMs with EVM? No. The integration is already an expected part of EVMS, and the documentation clearly addresses technical performance measurement…To those who state we need documents to link technical performance with EVM − we already have them. To those who want Congress to dictate how we perform EVM − thanks but no thanks. We can handle EVM without enabling

legislation. We have the direction. We have the documentation. We may agree that we need more discipline in any given organization, but we don't need an Act of Congress to achieve it."

Randy Steeno leads the NDIA Integrated Program Management Division (IPMD) EIA-748 Working Group. In February 2018, he presented the results of industry surveys in 2017 which concluded "Do not add a guideline for Program Management but do add one for Risk Management."[16]

Use the PMBOK® Guide to Achieve IPM

PMBOK® Guide includes standards and principles that meet the needs of IPM but are absent from EIA-748 (Table 5).

Table 5. *PMBOK® Guide* Standards and Principles that are Absent from *EIA-748*	
Standard or Principle	**Description**
Product scope description	**Documents the characteristics of the product that the project will be undertaken to create. Progressively elaborates the characteristics of the product.**
Product scope	**The features and functions that characterize a product.**
Requirements Documentation	**Requirements baseline; unambiguous (measurable and testable), traceable, complete, consistent, and acceptable to key stakeholders. Components include, functional requirements, non-functional requirements, quality requirements, and acceptance criteria.**
Requirements	**Requirements become the foundation of the WBS. Cost, schedule, quality planning, and procurement are all based on these requirements.**
Requirements Management Plan	**Include…product metrics that will be used.**
WBS Dictionary	**Includes quality requirements, acceptance criteria.**
Scope Baseline	**Includes product scope description, project deliverables, and defines product user acceptance criteria.**
Control Scope	**The process of monitoring the status of the project and *product* scope and managing changes to the scope baseline. Completion of the *product scope* is measured against the product requirements.**
Requirements Traceability Matrix	**Includes requirements to project (including *product*) scope/WBS objectives, product design, test strategy and test scenarios.**
Conduct Risk Management	**Including planning, identification, risk analysis, response planning, and monitoring risk.**
Risk Responses in Baselines	**Schedule baseline. Changes in the schedule baseline are incorporated in response to approved changes in schedule estimates that may arise from agreed-upon risk responses.** **Cost baseline. Changes in the cost baseline are incorporated in response to approved changes in cost estimates that may arise from agreed-upon risk responses.**
Project Procurement Management	**Project documents that can be considered as inputs to this process include:** • **Requirements documentation may include…technical requirements the seller is required to satisfy, and**

	• **Requirements traceability matrix…links product requirements from their origin to the deliverables that satisfy them.** • **Work Performance Data contains seller data on project status such as technical performance activities that have started, are in progress, or have completed; and costs that have been incurred or committed.** • **Work Performance Information includes information on how a seller is performing by comparing the deliverables received, the technical performance achieved, and the costs incurred and accepted against the SOW budget for the work performed.**

An organization can migrate from its current EVMS practices to IPM by incorporating the PMBOK® Guide standards and principles into its policies, procedures, training, and practices.

Federal Mandate for Program and Project Management (P/PM)

The use of PMBOK® Guide standards and principles by program managers in U.S. executive agencies will also aid in complying with PMIAA. PMIAA requires the Office of Management and Budget (OMB) to:

- Adopt and oversee implementation of government-wide standards, policies, and guidelines for P/PM for executive agencies;
- Establish standards and policies for executive agencies consistent with widely accepted standards for P/PM planning and delivery;
- Establish a 5-year strategic plan for P/PM.

The National Academy of Public Administration (NAPA) recommended that PMI standards be considered by the OMB as a VCS for PMIAA implementation.[17] NAPA also cited PMBOK® Guide and stated that "that agencies in the federal government already utilize the standards published by PMI when looking to strengthen or develop program and project management in their agencies."

PMIAA P/PM Competencies

The U.S. Office of Personnel Management (OPM), in consultation with the OMB and the Program Management Policy Council, defined "P/PM competencies to select, assess, and train program and project management talent for the 21st century,"[18] including four technical competencies which are absent from EIA-748. The competencies identified will inform future work currently underway in support of OMB's 5-year strategic plan for implementing the PMIAA (including standards for P/PM)."

1. Quality Management - Knowledge of the principles, methods, and tools of quality assurance, quality control, and reliability used to ensure that a ***project, system, or product fulfills requirements and standards.***
2. Requirements Management - Knowledge of the principles and methods to identify, solicit, analyze, specify, design, and ***manage requirements***.
3. Risk Management - Knowledge of the principles, methods, and tools used for ***risk*** assessment and ***mitigation***, including assessment of failures and their consequences.

4. Scope Management - Knowledge of the strategies, techniques, and processes used to plan, monitor, and control project scope; includes collecting requirements, defining scope, creating a work breakdown structure, validating scope, and ***controlling scope to ensure project deliverables meet requirements (i.e., features, functions)*.**

The PMBOK® Guide Standards and Principles in Table 5 are consistent with OPM/OMB and WSARA objectives.

Practical Guidance for P/PM

The integration of TPM with EVM began in 1991. The Program Executive Office for several Navy programs began an effort to integrate technical performance with cost and schedule metrics. That effort was later transferred to the Office of the Secretary of Defense (OSD). Several practical benefits accrued by the integration of technical metrics through earned value in this project. First, cost impacts were informed by technical achievement vice work accomplishment thereby strengthening the credibility of EVM metrics. Second, sufficient early warning of technical perturbations in contract performance were identified to allow for mitigation of risk resulting in cost avoidance. The ultimate objective of the OSD project in integrating TPM with EV was to facilitate the acceptance of this and similar methodologies by private industry in the area of complex program management. The benefits of the effective and proactive employment of technical risk management were expected to accrue both to the American taxpayer through cost avoidance and improved readiness, and to private industry through more profitable and successful commercial projects. It was intended to be the next logical step in developing integrated program tools to support the new paradigm of systems thinking.[19]

Elements of P/PM, including SE, were implemented on the B-2 program in 1998. The Air Force published a "Success Story" which stated that the program "implemented several innovative process improvements using EVM. These included integrating EV with SE processes, defining improved software engineering metrics to support EVM,...key metrics are defined at higher levels to best measure technical performance…These changes paid off during upgrades of the B-2 weapon system…The methodology was used to ensure that the warfighter received the most functionality from software development efforts. On Joint Standoff Weapon/Generic Weapon Interface System, we provided 85% more capability than originally planned, on schedule and under budget."[20]

Practical guidance and examples for implementing P/PM are provided in a tutorial that was presented at the 2018 NDIA SE Conference.[21]

Conclusion

CPM and the U.S. government recognize the need to integrate P/PM principles and standards with EVMS. The use of EIA-748 by itself is insufficient to achieve those objectives.

EIA-748 focuses on the work, not the product. It describes the Performance Measurement Baseline but is silent on the technical baseline or product scope.

Organizations should augment their EVMS process with project management standards, principles, and guidelines that are consistent with PMBOK® Guide to achieve CPM, OMB, and/or DoD integration objectives. In Mr. Finneran's words, program managers should "***Make the product the boss***" and should talk about the cost and schedule based on EVM data, ***quality, and technical performance…risks and risk mitigation.*** PMBOK® Guide can get them there.

Author Biography

Paul Solomon retired from Northrop Grumman in 2008 where he supported the F-35, B-2, and Global Hawk programs. He advocates process improvements and acquisition reforms to integrate P/PM and SE with EVM. He was on the team that wrote the EVMS Standard and received the DoD David Packard Excellence in Acquisition Award. He was a Visiting Scientist at the CMU/SEI. He taught EVM to commercial IT companies in India and South Korea.

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Note: All citations by Solomon, P. may be downloaded at www.pb-ev.com .