Chapter 1
Overview of PBEV

INTRODUCTION

This chapter describes the current state of Earned Value Management (EVM) and explains the need for a new generation of earned value techniques. Both major stakeholders, customer and supplier, need a project management tool that truly integrates a project's cost, schedule, and technical performance objectives, can be tailored to enterprise and project needs, can be utilized at the lowest possible cost, and supports shorter project cycle times. The characteristics and limitations of traditional EVM are examined. The characteristics and advantages of Performance-Based Earned Value (PBEV) are introduced. These will be amplified and clarified in the remainder of the book and applied to a typical systems development project.

WHAT IS PBEV?

Performance-Based Earned Value (PBEV) is an enhancement to the Earned Value Management Systems (EVMS) national standard. PBEV supplements EVMS with principles and guidelines for true integration of project cost, schedule, and *technical* performance. It is derived from standards and capability and maturity models for systems engineering and project management. PBEV overcomes several limitations of EVMS with regard to customer satisfaction and risk management.

PBEV addresses customer satisfaction by incorporating product requirements and planned quality into the Performance Measurement Baseline (PMB). EVMS addresses only the *quantity of work* completed.

Performance-Based Earned Value, by Paul J. Solomon and Ralph R. Young

The customer is satisfied when all *product requirements* have been met, including the expected *quality*. However, EVMS states that the *quality* and *technical content* of the work performed are controlled by *other means*. Consequently, a supplier's application of EVMS may be compliant with the EVMS guidelines but fail to report deviations from the plan to meet the product requirements. PBEV enables true integration of technical performance with cost and schedule performance by linking work packages to milestones for meeting the product requirements. PBEV includes milestones that have documented success criteria and objective measurement of progress toward those milestones.

PBEV also incorporates the outcomes of risk management into revised plans and the Estimate at Completion (EAC). Although EVMS is called a risk management tool, it is silent on the topic of risk management.

PBEV supports agile systems development because it is scalable to match the project risk and is responsive to changing product requirements. PBEV evolved from lessons learned in both the U.S. defense industry and the commercial software industry in India. It is a cost-effective method. The principles and guidelines of PBEV provide a framework for process improvement.

PBEV CHARACTERISTICS

PBEV is a set of principles and guidelines that specify the most effective measures of cost, schedule, and technical performance. It has several characteristics that distinguish it from traditional EVMS:

1. **The plan is driven by product requirements, not work requirements.**
2. **Earned value is based on technical maturity and quality, in addition to work completed.**
3. **Technical performance is determined by meeting success criteria of technical reviews.**
4. **The approach:**
   a. **Adheres to standards and models for systems engineering, software engineering, and project management.**
   b. **Provides smart work package planning.**
   c. **Enables insightful variance analysis.**
   d. **Ensures a lean and cost-effective approach.**
   e. **Enables scalable scope and complexity of management control, depending on risk.**
   f. **Integrates risk management activities with the PMB.**
   g. **Incorporates quantified risk assessment into the EAC.**
   h. **Is applicable to all development models and methods, including agile methods.**

PBEV enables quantitative project management with a high degree of confidence in the reliability and validity of the earned value information. It contributes to project success by signaling early warnings of deviations from systems engineering and other technical plans. PBEV evolved by responding to lessons learned from projects that used legacy EVMS but experienced shortcomings in management visibility and control.

Advice on how to apply PBEV in practice is given in subsequent chapters. To help the reader appreciate the advantages of PBEV, we will first examine the reputation of EVM.

REPUTATION OF EARNED VALUE MANAGEMENT

EVM is defined as a project management tool that effectively integrates the project scope of work with cost, schedule, and performance elements for project planning and control [1]. The Project Management Institute (PMI) states that EVM has proven itself to be one of the most effective performance measurement and feedback tools for managing projects [2]. The PMI standard, Project Management Body of Knowledge (PMBOK® Guide), describes earned value analysis as the most commonly used method of performance measurement [3].

If properly implemented, EVM enables quantitative project management with a high degree of confidence in the reliability and validity of the earned value information. A project manager (PM) can know how efficiently resources are being managed and can use standard mathematical formulae for estimating the project's final costs. EVM contributes to project success by signaling early warnings of deviations from cost and schedule plans. The early warnings allow the PM to take prompt corrective actions to bring the project under control. By using EVM, the PM and the customer expect to understand the status of the project and the most likely outcome at project completion. They hope to avoid unpleasant surprises.

LESSONS LEARNED

Unfortunately, we have observed many PMs and customers who used EVM but were unable to avoid unpleasant surprises. It later turned out that the previous earned value information had reported work progress but failed to account for technical performance that was behind schedule. Consequently, the information overstated the efficiency of project resources and understated the estimates of the final project cost and completion date. Furthermore, the projects incurred significant costs just in administering the EVM processes and reporting EVM status.

As employees of a major corporation that uses EVM on large federal and defense contracts and as taxpayers who pay for the contracts, we want EVM to be a useful project management tool that enables project success. Yet, many stakeholders (including us) have asked:

> Why was the previous earned value information misleading and invalid?
>
> Why are we spending so much money on EVM and not receiving adequate business value?
>
> How can we use EVM more effectively?

Some of the lessons learned by examining the root causes of the unpleasant surprises follow.

Inadequate Early Warning

The use of EVMS has often failed to provide adequate early warning of significant future deviations from project objectives. The customer sometimes has received unpleasant surprises. As discussed above, post mortems and lessons learned disclosed that the previously reported earned value information had overstated technical progress and maturity and understated the impacts on completion objectives.

Poor Implementation of EVMS

Some project surprises are the result of poor implementation of EVMS. There may have been insufficient training, a lack of involvement and urgency by top management, and failure to used the earned value data to detect and control variances. PBEV will not prevent or overcome such lapses in management and discipline.

Reliable, Valid Information

EVM data will be reliable and valid only if:

1. **The right base measures of technical performance are selected.**
2. **Progress is objectively assessed.**
3. **The indicated quality of the evolving product is measured.**

Product Requirements and Quality

Earned value taken should reflect progress toward meeting the product requirements and the expected quality of the product that is being developed. A product requirement is a statement that identifies a product operational, functional, or design characteristic or constraint, which is unambiguous, testable or measurable, and necessary for product or process acceptability (by consumers or internal quality assurance guidelines). Quality is the degree to which a set of inherent characteristics of a product or product component fulfills requirements of customers.

Processes

EVM's effectiveness as a measure of performance depends on the capability and maturity with which the organization performs the related processes for systems engineering (SE) (including software engineering) and project management. The most pertinent SE processes for PBEV are requirements development, requirements management, and performance-based progress measurement.

Measures

Finally, if you are measuring the wrong things or not measuring the right way, then EVM may be more costly to administer and may provide less management value [4].

This book provides a framework and practical guidance for utilizing EVM as a key component of project planning, measurement, and control. The framework is primarily based on actual project experience, and it is also guided by standards and capability models for EVM, systems engineering, software engineering, and project management. The techniques that follow have been used in successful, software-intensive projects and provide the most business value for the money. We call it *Performance-Based Earned Value*.

SNAPSHOT OF EVM

Before EVM, Project Managers (PMs) tracked cost and schedule performance independently of each other. Actual expenditures of resources were compared with planned expenditures through a point in time to determine a so-called cost variance. The actual progress of activities was compared with scheduled activities to determine the schedule variance in measures of time. However, there was no unifying measure that valued the progress of the activities (physical work accomplished) in measures of the resources that were planned for that accomplishment. That measure is earned value (EV).

EVM compares the amount of work that was planned (Planned Value or PV) with what was actually accomplished, EV, to determine whether project cost and schedule performance were achieved as planned. The U.S. standard for EVM includes the following principles:

1. **Decompose the program work scope into finite pieces that can be assigned to a responsible person or organization for control of technical, schedule, and cost objectives (control accounts and work packages).**
2. **Integrate program work scope, schedule, and cost objectives into a performance measurement baseline (PMB) against which accomplishments can be measured.**
3. **Objectively assess accomplishments at the work performance level.**
4. **Analyze significant variances from the plan, forecast impacts, and prepare an estimate at completion (EAC) based on performance to date and work to be performed.**

EVM uses two performance indices that enable effective analysis and forecasting. The Cost Performance Index (CPI) is the cost efficiency of the resources that were expended. The Schedule Performance Index (SPI) is the ratio of schedule progress against the plan based on budgeted resources, not time. Individually or in combination, the CPI and SPI provide single-point and trend analyses of project performance and statistical forecasts of the EAC that would be attained if the PM failed to make corrective actions to the plan for the remaining work.

A primer on the fundamentals of EVM is provided in Appendices A and B.

EVMS HISTORY AND LIMITATIONS

EVMS History

EVM was used by the U.S. Department of Defense (DoD) to monitor the acquisition of large-scale, high-risk systems. Later, U.S. federal policy for nondefense agencies also required that suppliers use an Earned Value Management System (EVMS). In recent years, EVM has been adapted for use in commercial projects, including software-intensive projects. The EVM standard, EVMS, transformed government contractual requirements into a national standard. However, there are several limitations of the EVMS standard that inhibit its potential to integrate a project's cost, schedule, and technical objectives.

EVMS Limitations

EVM was initially developed to monitor the acquisition of large-scale, high-risk systems. EVMS was the result of transforming government contractual requirements into a national standard. However, EVMS has several shortcomings with regard to best practices in systems engineering and project management.

1. EVMS states that EV is a measurement of the *quantity* of work accomplished. Its discussion states that the quality and technical content of work performed are controlled by *other processes* (EVMS, Section 3.8). A project manager (PM) should ensure that EV also measures the *product quality* and technical maturity of the evolving technical work products instead of just the quantity of work completed.

2. The EVMS principles address the only the *work scope* of a project. They ignore the *product scope* or the product requirements. On the other hand, the systems engineering standards and models address the product requirements and require assessment of progress against requirements, technical performance, design maturity, and the quality of the product being developed. The PMBOK Guide differentiates two components of scope: product scope and project (work) scope. The PMBOK Guide also includes the quality baseline within the product scope and includes the quality baseline as part of the PMB.

3. EVMS encourages but does not require precise, quantifiable measures. It states that objective earned value methods are preferred, but it also states that management assessment (subjective) may be used to determine the percentage of work completed. In contrast, the PMBOK Guide and the capability model cited below provide specific guidance regarding objective measurement.

4. EVM is sometimes described as a risk management tool. However, EVMS provides no guidance on risk management and does not even mention the word "risk." By the time a significant cost or schedule variance exists, it is already an issue that should be addressed. It should not be misclassified as a risk. The variance will remain an issue until it is mitigated or until an effective corrective action plan is in place.

5. EVM is capable of providing powerful measures for measurement, analysis, and control. However, EVMS provides very little guidance for specifying the types of measures that meet management needs and objectives.

6. Finally, measurement costs money. There are significant costs to implement and use EVM. These costs can be reduced if the enterprise has an effective process to determine its information needs and objectives and to specify only those measures that meet those needs and objectives.

In summary, EVMS is a standard that lacks specific guidance on product requirements, quality, and risk management. It does not provide needed guidance for measuring progress toward meeting the customer's requirements. This book supplements EVMS with helpful guidance.

The following guidance will help a PM to understand and implement PBEV as a process improvement, in accordance with standards and models. It will enable EVM to be a more effective component of an integrated management system.

CUSTOMER EXPECTATIONS FOR PERFORMANCE-BASED MANAGEMENT SYSTEMS

Both the U.S. federal government and its military and civilian agencies have policies and acquisition regulations that require performance-based management systems.

U. S. Federal Policy

The U.S. government has acquisition policies and regulations that specify performance-based measurement. The Office of Management and Budget (OMB) requires that all agencies of the government that are subject to Executive Branch review must use a performance-based acquisition management system, based on EVMS, to obtain timely information regarding the progress of capital investments [5]. The system must *measure progress toward milestones* in an independently verifiable basis, in terms of cost, *capability of the investment to meet specified requirements*, timeliness *and quality* (Section 300.5). Both the government and contractors must demonstrate the use of an EVMS for development efforts (Exhibit 300, Part 1 H).

OMB has issued this policy to implement federal statutes, notably the Federal Acquisition Streamlining Act of 1994, Title V (FASA V) and the Information Technology Management Reform Act of 1996 ("Clinger–Cohen"). Federal Acquisition Regulations (FAR) requires the use of an EVMS that complies with the guidelines of ANSI/EIA Standard-748 for major acquisitions for development, in accordance with OMB Circular A-11 and that EVMS requirements will be applied to both prime contractors and subcontractors. One FAR clause requires the Government to conduct Integrated Baseline Reviews to assess the degree to which the management process provides effective and *integrated technical/schedule/cost planning and baseline control*. More information about these topics is in Chapter 14, *Supplier Acquisition Management*, and in Appendix D, *FAR Clauses*.

U.S. Department of Defense Policies

The Department of Defense (DoD) acquisition policy also requires specified suppliers to use performance-based management systems that meet OMB requirements for EVMS. However, DoD also has a policy and guidance regarding the use of systems engineering plans and the integration of systems engineering with EVM. The systems engineering standards that are referenced in the guidance were used as a basis for PBEV.

Integrating Systems Engineering with Earned Value Management

Compliance with the systems engineering standards will support DoD acquisition policy that programs implement systems engineering plans [6]. That policy is a result of DoD analyses that show a definite linkage between escalating costs and the ineffective application of systems engineering [7]. Consequently, the DoD has made the revitalization of systems engineering a priority. Systemic, effective use of systems engineering is a key acquisition management planning and oversight tool.

Regarding requirements, Wynne and Schaeffer add that the earlier in a program's life cycle that requirements are intensively managed by the systems engineering processes, the greater the likelihood that the program's cost and schedule estimates will be on target. Many programs trace their rising costs and lagging schedules to requirements-based problems such as poor program definition, lack of traceable allocations, and incomplete or weak verifications. Key to the successful implementation of systems engineering is the relationship between program management, contract management, and financial management.

Guidance documents that support the DoD policy include a systems engineering chapter in the Defense Acquisition Guidebook (DAG) [8], the Systems Engineering Plan (SEP) Preparation Guide (SEP Guide) [9], Work Breakdown Structure Handbook, MIL-HDBK-881A (WBS) [10], and the Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide (IMP/IMS) [11]. The guides provide discretionary best business practices to complement the policy. Table 1.1 shows pertinent components of the policy and guides.

National Defense Industrial Association

The National Defense Industrial Association (NDIA) Program Management Systems Committee (NDIA PMSC) also recommends integrating SE with EVM, as follows:

> With EVM expanding rapidly across the global project management community, project-based organizations can use EVM effectively to integrate systems engineering, cost estimating, contracting and risk

management for program/project management by government and contractor communities whenever the use of EVM is required. It is recommended for all program management stakeholders . . . The baseline of a program needs to be described in technical terms and requirements (size, weight, capability, performance, etc.). These requirements are determined through the systems engineering process. This process provides a clearer understanding of the program as knowledge of the end product is better defined. [12].

Standards and Capability Models

The following standards and capability models provide the foundation for PBEV principles and guidelines:

TABLE 1.1 DoD SE Policy and Guideines

Policy or Guideline	Policy	DAG	SEP Guide	WBS	IMP/ IMS
Develop Systems Engineering Plan (SEP).	P	4.2.3.2	1.0		
Event-driven timing of technical reviews	P	4.5.1	3.4.4	3.2.3.1	2.3, 3.3.2
Success criteria of technical reviews	P	4.5.1	3.4.4	3.2.3.1	3.3.2
Assess technical maturity in technical reviews.		4.5.1	3.4.4	3.2.3.1	
Integrate SEP with Integrated Master Plan (IMP).		4.5.1	3.4.5		1.2, 2.3
Integrate SEP with Integrated Master Schedule (IMS).		4.5.1	3.4.5		1.2, 2.3
Integrate SEP with Technical Performance Measures (TPM).		4.5.1	3.4.4		1.2, 2.3
Integrate SEP with Earned Value Management (EVM).		4.5.1	3.4.5		1.2, 2.3
Integrate WBS with requirements specification, statement of work (SOW), IMP, IMS, and EVMS.				2.2.3, 3.2.3.3	3.4.3
Use TPMs to compare actual vs. planned technical development and design maturity.		4.5.5	3.4.4		3.3.2
Use TPMs to report degree to which system requirements are met in terms of performance, cost and schedule.		4.5.5	3.4.4		
Use standards and models to apply systems engineering.		4.2.2 4.2.2.1			
Institute requirements management and traceability.		4.2.3.4	3.4.4		
Use EVM.		11.3.1			

1. **Earned Value Management Systems (EVMS)**
2. **Standard for Application and Management of the Systems Engineering Process (IEEE 1220) [13]**
3. **Processes for Engineering a System (EIA 632) [14]**
4. **Capability Maturity Model Integration (CMMI) [15]**
5. **A Guide to the Project Management Body of Knowledge (PMBOK Guide) [3]**

The DAG references CMMI, EIA 632, and IEEE 1220 as examples of standards and models. The DAG cites EIA 632 and IEEE 1220 as primary standards that an organization would most likely need to accomplish systems engineering.

CUSTOMER DEMAND FOR EXCELLENT PROCESSES

If an enterprise's processes are consistent with the SE standards, it will support the DoD policy that a program must implement a SEP. The related guidance states that the SEP will address the integration of the technical aspects of the program with the overall program planning, SE activities, and execution tracking to include:

1. **The SE processes (from a standard, a capability model, or the contractor's processes)**
2. **Discussion of metrics [e.g., Technical Performance Measures (TPM) for the technical effort and how these metrics will be used to measure progress]**
3. **Event-driven timing, conduct, success criteria, and expected products of technical reviews and how technical reviews will be used to assess technical maturity, assess technical risk, and support program decisions**

CMMI AS A FRAMEWORK FOR PROCESS IMPROVEMENT

Suppliers to both commercial and government customers have used capability models to improve processes and obtain competitive advantage. The DoD policy cites a capability model as a source of SE processes. In Chapter 15, *Moving Forward*, guidance is provided for using CMMI as a framework for process improvement. PBEV is consistent with informational guidance in CMMI.

CUSTOMER NEEDS FOR REDUCED CYCLE TIME AND EVOLUTIONARY ACQUISITION

Commercial enterprises normally demand short product development cycle times to remain competitive. They must be able to respond to rapidly changing customer requirements.

The DoD has reformed its acquisition policies to encourage reduced cycle times. DoD policy (DoD Directive 5000.1, 2003) [16] states that advanced technology shall be integrated into producible systems and deployed in the shortest time practicable. Evolutionary acquisition strategies are the preferred approach to satisfying operational needs. Spiral development (described below) is the preferred process for executing such strategies.

DoD's guidance (DoD Instruction 5000.2, 2003) [17] for implementation of the policy states that an evolutionary approach delivers capability in increments, recognizing, up front, the need for future capability improvements. The success of the strategy depends on the consistent and continuous definition of requirements and the maturation of technologies that lead to disciplined development and production of systems that provide increasing capability toward a materiel concept. The approaches to achieve evolutionary acquisition include the following:

1. ***Spiral Development*. In this process, a desired capability is identified, but the end-state requirements are not known at program initiation. Those requirements are refined through demonstration and risk management; there is continuous user feedback; and each increment provides the user the best possible capability. The requirements for future increments depend on feedback from users and technology maturation.**
2. ***Incremental Development*. In this process, a desired capability is identified, an end-state requirement is known, and that requirement is met over time by development of several increments, each dependent on available, mature technology.**

PBEV supports evolutionary acquisition because of its continual focus on the product requirements baseline, including:

1. **Traceability of schedule and cost plans to the known requirements**
2. **Specific guidance on the requirements development phase, including trade studies**
3. **Focus on measuring progress toward implementing the requirements**
4. **Guidance stating that changes to the product requirements baseline drive changes to the performance measurement baseline**

INCREASING UTILIZATION OF EVM

There is increasing interest in the utilization of earned value to control commercial systems development projects. For example, two conferences on project management were held in India in 2004 and 2005. The attendees were primarily members of the commercial software industry. Representatives from Infosys, Alcatel, Satyam Computer Services, and Wipro submitted papers on the use of EVMS.

Guidance on PBEV was presented in Bangalore, Delhi, and Hyderabad by Paul Solomon. The software industry in India intends to improve its project management processes to achieve competitive advantage, just as it did with its software engineering processes. Leading-edge Indian companies are beginning to use EVM as part of their tool set.

PBEV AND AGILE METHODS

The need for reduced cycle time and evolutionary acquisition has been a catalyst for project managers to consider using agile development methods. Agile methods are discussed in Chapter 11.

PBEV can support agile systems development. Because it uses requirements-based planning and performance-based measurement, it enables innovation, flexibility, and focus on outcomes instead of non-value-adding processes. Also, PBEV Guidelines 4.1 and 4.2 support agility by tailoring the application of PBEV. Discrete measurement may be applied only to the higher-risk components of the WBS and may be deferred until the initial requirements have been developed.

ENTERPRISE DEMAND FOR COST-EFFECTIVE PROCESSES

As noted above, measurement costs money and an enterprise must incur significant implementation and sustaining costs in order to utilize EVM. These costs can be reduced if the enterprise utilizes an effective process to determine what needs to be measured and limits the measurements to those that meet its information needs and objectives. PBEV incorporates guidance for selecting measures from the standards and models discussed above. Consequently, PBEV can cost less than traditional EVM if the number of measures is reduced. Furthermore, management can control the project more effectively if it focuses on fewer but more critical measures.

EVOLUTION OF PBEV

PBEV was developed incrementally. It began with a series of process improvements within a sector of the Northrop Grumman Corporation. The improvements were initially driven by the need to provide performance measurement of software development at the Northrop

Grumman Corporation Integrated Systems Sector. One of the authors (Solomon) teamed with program management and with the software engineering process group to develop new practices. The first set of improvements used Practical Software and Systems Measurement (PSM) [18] as a framework for process improvement. PSM has principles for identifying, collecting, and tracking project measures that produce work products. Examples of performance-based measures for earned value include functional requirements status, component status, test status, and increment content-function.

These changes paid off during upgrades of the B-2 weapon system. The new metrics helped to make it a very successful program. The PBEV methodology was used to ensure that the warfighter received the most functionality from software development efforts. "The B-2 Spirit Stealth Bomber Program implemented several innovative process improvements using EVM. These include integrating earned value with systems engineering processes, defining improved software engineering metrics to support EVM, and developing a leaner, more effective methodology called performance-based earned value (PBEV)" [19]. A description of these early process improvements and the resultant practices is provided in Solomon, "Practical Software Measurement, Performance-Based Earned Value" [20].

The next evolution incorporated practices from Capability Maturity Model Integration (CMMI), especially those concerning requirements management and measurement. While teaching the use of EVM at the Software Engineering Process Group Conference in India, Paul Solomon was questioned about the relationship between the EVMS guidelines and CMMI. Many of the software companies in India were achieving high levels of CMMI capability. Concurrently, many defense companies in the U.S. were starting to use the CMMI model to improve their capabilities. Solomon, working with the Software Engineering Institute (SEI), published a paper that provides guidance for using CMMI as a framework for improving EVM processes and includes tables that map CMMI practices and information needs to EVMS guidelines [21].

The systems engineering standards cited earlier provide additional guidance for meeting customer requirements including coverage of technical performance measurement (TPM) and success criteria for technical reviews. Finally, the principal tenets of PBEV included guidance from the PMBOK Guide regarding risk management and TPM.

Process improvement at the Northrop Grumman Integrated Systems Sector is ongoing, with the primary frameworks for improvement being

Institute of Electrical and Electronic Engineers (IEEE)-1220, CMMI, and IS0/IEC 15288.

A second visit to India by Paul Solomon provided ideas for adapting PBEV to incorporate some objectives of agile methods. While teaching EVM during the first International Project Management Leadership Conference (Bangalore, 2004), he and students discussed ways to tailor PBEV so that it could support the goals of agile development methods. Some of these ideas are incorporated into PBEV Guidelines 4.1 and 4.2.

COMPARISON OF PBEV WITH EVMS

The principles of EVMS are a foundation for PBEV. However, PBEV adds four principles that enable more effective project management. A comparison of the principles of EVMS and PBEV is shown in Table 1.2.

TABLE 1.2 EVMS and PBEV Principles

Principle (E) = EVMS (P) = PBEV	EVMS	PBEV
(E) Plan all work scope to completion.	Y	Y
(P) Integrate product requirements and quality into the project plan.	N	Y
(E) Break down work scope into finite pieces that can be assigned to a responsible person or organization for control of technical, schedule, and cost objectives.	Y	Y
(E) Integrate project work scope, schedule, and cost objectives into a performance measurement baseline (PMB) against which accomplishments may be measured. Control changes to the baseline.	Y	Y
(P) Specify performance toward meeting product requirements, including planned quality, as a base measure of earned value (EV).	N	Y
(E) Use actual costs incurred and recorded in accomplishing the work performed.	Y	Y
(E) Objectively assess accomplishments at the work performance level.	Y	Y
(E) Analyze significant variances from the plan, forecast impacts, and prepare an estimate at completion based on performance to date and work to be performed.	Y	Y
(E) Use EVMS information in the company's management process.	Y	Y
(P) Integrate risk management with earned value management (EVM).	N	Y
(P) Tailor the application of EVM according to the risk.	N	Y

EVMS Process Flow

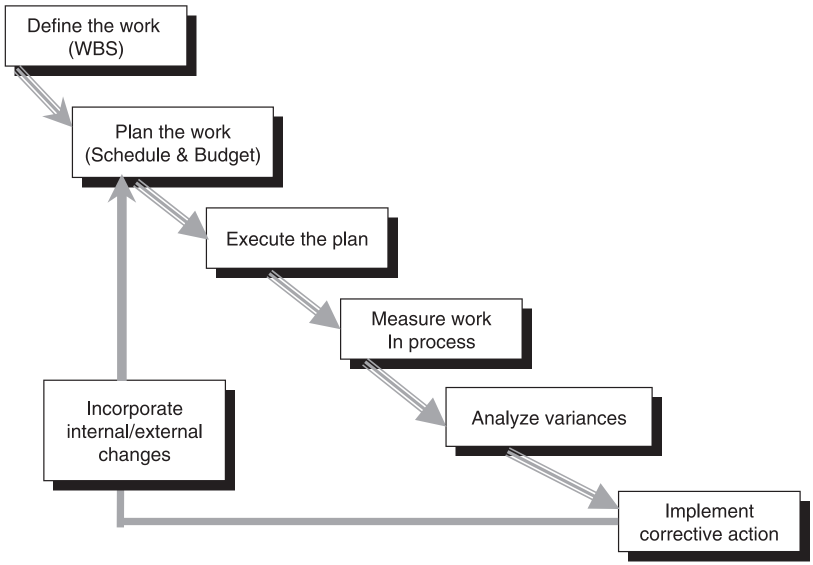

FIGURE 1.1 EVMS Process Flow.

PBEV PROCESS FLOW

The PBEV process flow is consistent with the EVMS process flow but has additional processes regarding the product requirements and risk management. Figures 1.1 and 1.2 show the EVMS process flow (Figure 1.1) and the PBEV process flow (Figure 1.2).

The PBEV processes and guidelines that supplement EVMS are highlighted in Figure 1.2. PBEV includes three processes that supplement EVMS and that address the product requirements:

1. **Define the product (also called the technical baseline).**
2. **Integrate product requirements and quality with the plan.**
3. **Measure progress toward meeting product requirements and quality.**

An additional PBEV process addresses risk management:

4. **Integrate risk management with the plan.**

ABOUT THIS BOOK

The following chapters provide guidance and examples to illustrate improved practices that follow the guidelines of PBEV. When appro-

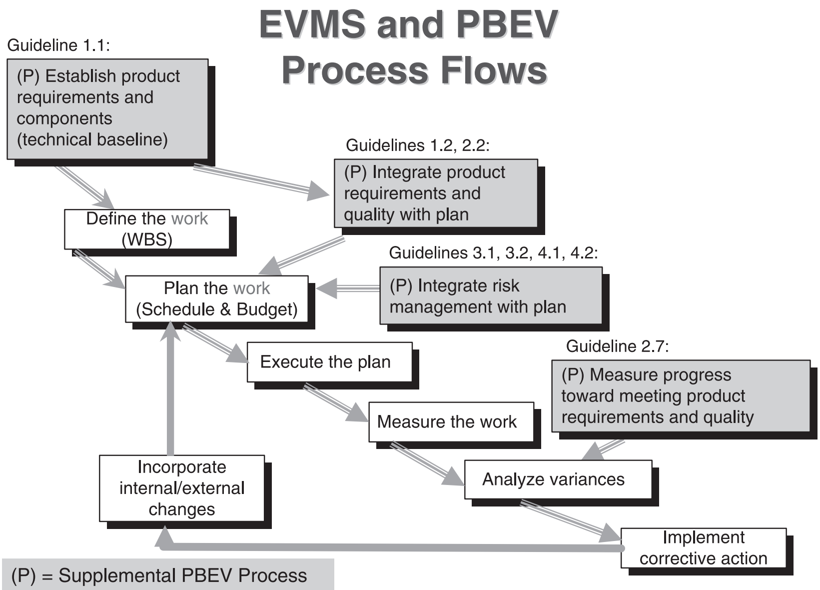

FIGURE 1.2 PBEV Process Flow.

priate, the guidance in this book will cite and display the references from the standards and models that are a foundation of PBEV. A complex engineering development project is introduced in Chapter 4. That project demonstrates the importance of managing requirements with effective systems engineering processes. Examples from the project are continued in subsequent chapters when additional PBEV guidelines are applied.

This book augments legacy or traditional EVMS. The authors assume that the readers understand the principles, guidelines, and practices of traditional EVMS. However, for readers who are new to EVM and for those who need to understand EVMS to meet educational or professional certification requirements, the fundamentals of traditional EVMS are covered in Appendices A and B.

A real, nontechnical project is described, planned, and measured to reflect the role of the Project Manager.

The chapters and appendices include examples of best practices that are instructional and that can be used as templates for using EVM on your project. Appendices C, C-1, and D include useful information and references for customers and suppliers that must comply with the EVMS guidelines. Appendices E through I include guidance and examples for managing technical performance and the technical baseline.

Chapter 14, *Supplier Acquisition Management*, will help the customer to ensure that its suppliers use EVM effectively. All other chapters are intended to benefit both customers and suppliers. We hope that you will consider applying the PBEV guidelines to your project and that both parties will reap the benefits of high customer satisfaction.

SUMMARY

This chapter has reviewed the current state of EVM. The authors assert that there is a need for a new generation of earned value techniques: Performance-Based Earned Value (PBEV). Customers and suppliers need a project management tool that fully integrates a project's cost, schedule, and technical performance objectives; can be tailored to enterprise and project needs; can be utilized at the lowest possible cost; and supports shorter project cycle times. The characteristics and shortcomings of traditional EVM were examined. The characteristics and advantages of PBEV were introduced. A comparison of PBEV with EVMS was provided. PBEV adds four principles that enable more effective project management.

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