Phase Earned Value Analysis: A Proposal for Simplifying yet Enhancing EVM[1]

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Introduction

In this paper, I describe Phase Earned Value Analysis (PEVA), which I have proposed (Bower, 2006) as a new extension to earned value management (EVM) theory and methodology that adapts and advances standard EVM concepts. In doing so, I explain how PEVA can provide effective performance measurement information without the rigor and complexity that is normally required by conventional EVM. PEVA achieves this through the recognition of phases as the key organising elements of projects and also by addressing and resolving several of the known challenges of conventional EVM.

I begin this investigation by reviewing the relevant literature on EVM and the issues related to its implementation. Following, I discuss PEVA's key elements and the procedures used to apply these elements. I also examine the recent work in the area of Earned Schedule. I then demonstrate the ease of applying this new PEVA approach — identifying its features and benefits and comparing it with current EVM techniques — via a hypothetical and simplified project situation.

EVM Context

The Project Management Institute (PMI) has defined EVM as "a management methodology for integrating scope, schedule, and resources, and for objectively measuring project performance and progress. Performance is measured by determining the budgeted cost of work performed (i.e., earned value) and comparing it to the actual cost of work performed (i.e., actual cost). Progress is measured by comparing the earned value to the planned value." (PMI, 2004; p. 359)

The benefits of adopting and using EVM are commonly touted within the defence and aerospace industries, particularly among the United States (US) organisations working within these industries. This embrace of EVM is linked to the US Department of Defense (DoD), which developed guidelines for adopting EVM, guidelines which actively promote and require DoD contractors to use EVM when implementing defence projects (Fleming & Koppelman, 2000). Despite EVM's demonstrated benefits, it has not been widely adopted in other industries where projects are managed.

There are numerous factors that could have slowed the adoption of EVM. Kim, Wells, & Duffery (2003) identified some of these factors. For example, EVM requires that the organisation possess a significant degree of project management maturity. In my professional experience, such maturity is not consistently available. For example, many organisations fail to include the cost of internal staff time when estimating project costs. Rarely do they use timesheets to track actual staff time devoted to specific projects and specific activities. (Such a practice is common among consulting firms and other groups that charge clients for their time.) Although these organisations establish project schedules, their project managers are not required to set a baseline, an element that is essential for analysing earned value. It is also difficult to identify work packages and related costs when organisations use poorly outlined scope definitions and change control practices.

In my previous research (Bower, 2004), I found that EVM lacks the additional information and certainty found in the procurement practices that are extensively used in many industries, including construction. I proposed using a new technique — Assured Value Analysis (AVA) — which could provide this additional information and certainty. Although AVA built on and extended conventional EVM methodology by embracing procurement management, it added complexity to a methodology that many project managers already perceived as overly demanding.

If EVM's complexity is preventing more organisations from using it, then one approach to expand its use is to improve the EVM skills of managers, while demonstrating its benefits to executives. Another valid approach is for researchers to determine whether they can simplify EVM and thereby increase its ac-

[1]*The contents of this article are not related to any projects or programs at the Province of Ontario.*

ceptance and use among managers in organisations with lower levels of project management maturity. It is this latter approach that I address in this paper, and in doing so, I explain how organisations can use PEVA as a method for simplifying EVM by using the project phases as natural groupings of both scheduled activities and budgeted costs.

Adapting EVM to Project Situations

PMI's *Practice Standard for Earned Value* Management (*PS-EVM*) (PMI, 2005) explained that "EVM needs to be tailored to fit the specific project situation" (p. 4). The *PS-EVM* argued that as project significance and uncertainty increase, the rigor with which organisations apply EVM also needs to increase. "There are two basic dimensions to EVM vigour, the granularity and frequency of the measurement of project performance" (p. 4). *PS-EVM* defined granularity as the level of detail used to categorise project scope using the work breakdown structure (WBS). It defined frequency as the time interval at which project performance is assessed, analysed, and reported, ranging from daily to monthly or longer. *PS-EVM* explained that "EVM implementation can be scaled along the dimensions of granularity and frequency to achieve the degree of vigour required by the significance and uncertainty of the project" (p. 4).

In this paper, I suggest that other key dimensions may exist other than the two recognised by *PS-EVM*. One of these dimensions involves the degree to which project deliverables are being provided by consultants and vendors. Procuring a large portion of the project deliverables from external sources can increase the need to align the approved budget with the procurement structure, which will, in turn, reduce the degree that the budget can be made to integrate with the schedule.

Another key dimension affecting EVM implementation is the degree to which the project implementation has been divided into stages or phases. Managers typically divide large and complex projects into recognisable phases to aid in planning, execution, and control. Dividing the deliverables into a series of phases may create difficulties in the creation of control accounts, which are seen as groupings of work packages. With a phased project approach, a set of similar deliverables by a given internal department or vendor may be implemented in a fragmented fashion, possibly in a range of separate locations or over several phases.

Challenges of Standard EVM

Cost and Schedule Integration Challenges

Conventional EVM practice requires that organisations completely integrate their project's scope, budget, and schedule (Cleland & Ireland, 2002). Fleming and Koppelman (2000) affirmed this point in their text on this technique.

Conventional EVM requires the project manager to develop a performance measurement baseline (PMB) involving both the cost budget and the approved time schedule. The key to such activity is creating control accounts that aggregately represent all project-related activities.

EVM appears to require that organisations create control accounts to group one or more work packages that are the responsibility of a specific project participant, such as an individual, department, division, supplier, vendor, or consultant. Each control account comprises a specific scope of work, an approved budget, a time schedule, and actual costs that are directly attributed to it. Fleming and Koppleman (2000) described the control account as a subproject because it comprises these self-contained characteristics. PMI (2004) proposed a definition of control accounts:

> *"Control Account (CA): A management control point where the integration of scope, budget, actual cost, and schedule takes place, and where the measurement of performance will occur. Control accounts are placed at selected management points (specific components at selected levels) of the work breakdown structure. Each control account may include one or more work packages, but each work package may be associated with only one control account. Each control account is associated with a specific organizational component in the organizational breakdown structure (OBS)." (p. 355)*

Creating the PMB may seem logical and straightforward in the context of EVM theory. In practice, however, many project managers find it difficult to integrate the schedule activities with the line items in the budget. Based on my experience and discussions with project managers, I suggest there are many reasons why such difficulties occur.

Corporate Accounting Codes

Many organisations require that project managers organise their project budgets according to pre-established major and minor divisions, using standardised names and cost codes. Using these standard divisions allows the organisation to more effectively collect, summarise, and analyse the costs for its projects and programs. If each project used project-specific cost categories and codes, then the process of summarising costs on an annual basis or by division would prove very challenging. By the same token, project managers may find it difficult to organise budgets to conform to corporate codes and simultaneously align budgets with WBS categories and control accounts.

Budgets Derived from Estimates

Budgets are normally based on cost estimates, which project managers may have prepared using estimating techniques or models that generate cost estimates in specific output formats. At the highest level, organisations might authorise a project to proceed prior to any detailed estimating, particularly if the project is very similar to one the organisation recently completed, one for which it knows the total costs involved. Although that previous project's cost breakdown is available, it could have been formatted according to the information provided by a major contractor.

A parametric estimating process can provide an extremely reliable cost estimate, but one that is not formatted or subdivided according to the WBS or control accounts. Several years ago, I developed a parametric model using a spreadsheet platform that could reliably estimate the cost and physical characteristics of a bank branch facility. The model used only a few parameters. The user input included the number of tellers, ATMs, loan officers, and vault safety-deposit boxes as well as a few items related to the characteristics of the building, such as the number of floors. The result provided a cost estimate grouped into appropriate categories, but those did not necessarily represent the expected WBS for the project.

In order for a detailed WBS to represent the budget categories, it would be necessary for that budget to be based on a detailed bottom-up estimate. Not all projects include the preparation of a detailed estimate, and those that do may not generate a detailed estimate until the project is well advanced. It is not reasonable or advisable to delay the preparation of the WBS and the earned value system until that point in the project.

Effect of Procurement

Projects that are internally delivered require no differentiation of the source of resources. That is, all staff resources are from the organisation that is sponsoring and implementing the project.

However, for those projects involving work provided by external sources (vendors and contractors), organisations must develop estimate and budget accounts that list these costs in a single section, one that correlates to the scope of the vendor and contractor agreements. That is, if there is just one contract with a vendor, then the organisation should summarise all of that work in one section of the budget. If there are several contracts with the same vendor, then the organisation should summarise — in separate sections of the budget — the work outlined in each of the contracts.

One of the key challenges with conventional EVM is that effective cost control requires a means to track budget against contract amount, draws, and payments for each vendor agreement. Those agreements may comprise a large and diverse range of work activities that cannot be neatly assigned to a cost account. For example, an engineering firm could be retained to provide a wide range of testing services through the full life cycle of the project. The budget could contain an amount based on previous experience, as a detailed cost estimate may be impossible. If the firm has been retained on a cost-plus basis, the actual costs for its work would become known only as the project proceeds. The activities performed by the engineering firm could occur at many different points in the project, resulting in many work packages that do not occur in a conveniently sequential block in the schedule.

In construction projects, contractors are usually responsible for the work they perform at many places on the site and at different times in the implementation schedule. For example, in the construction of an office building, concrete forming and placement occurs early on when making the footings and foundations, again during the pouring of the floor

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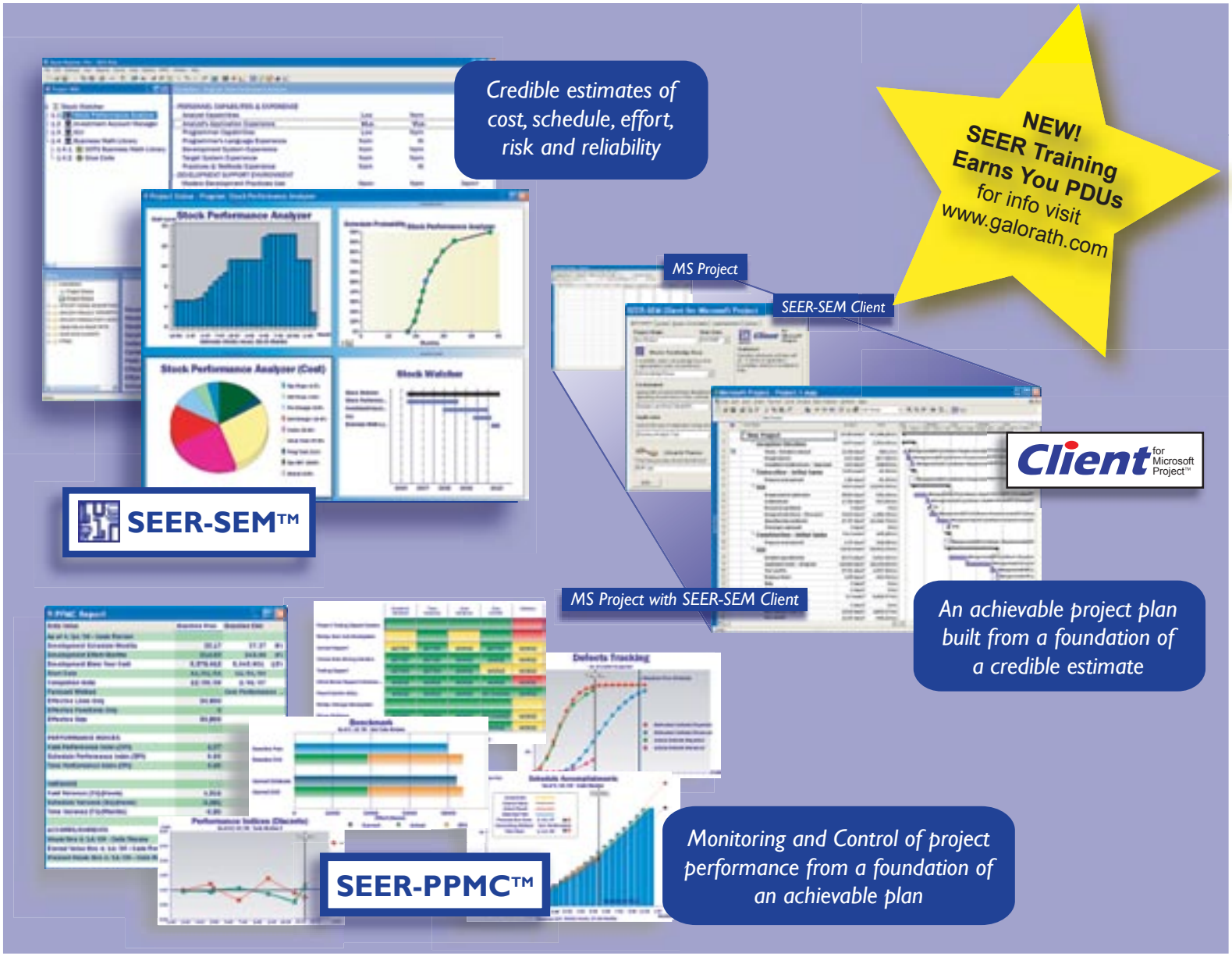

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slabs, and later during the installation of walkways and curbs. Although this concrete work obviously occurs at different points (involving numerous work packages) during the project schedule, these services are typically included in the same contract. As this shows, it is not convenient to consider all of those work packages as a single grouping on the schedule.

Breaking Down the Scope for Budget and Schedule

The project manager wishes to organize the budget according to cost elements. Those cost elements may be based on standard corporate formats, standard industry formats, such as that developed by the Construction Specifications Institute, and the expected division of the work among functional departments and external vendors.

In addition, the project manager wishes to organize the schedule according to time elements. Those time elements may be based on the planned stages of the work, the effect of annual seasons, the logical sequence of the activities, the phased rollout of the deliverables to various locations, the availability of staff or various other resources, the target milestones for deliverables, and many other determining factors. Why then must the cost baseline be integrated with the time baseline?

In its PMBOK® Guide, PMI (PMI, 2004) defined the WBS as "A deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables. It organizes and defines the total scope of the project" (p. 379). With this, PMI (PMI, 2004) defined a work package as "A deliverable or project work component at the lowest level of each branch of the work breakdown structure" (p. 380). This definition stresses that the WBS describes the work to be executed by the project team only. It does not describe the work performed by other individuals or organisations, work which impacts or contributes to the total project.

One can argue that the WBS must address a project's total scope and that the scope must summarise all of the items included in the WBS; however, there is the possibility that some WBS activities will not use any resources. Because of this, project managers might not list these activities in the budget. For example, the WBS might include crucial project activities carried out by the client at no cost to the project team.

The schedule may also contain activities that are not — strictly speaking — listed in the WBS; such activities might not directly contribute to the project deliverables. For example, the schedule may include milestones or activities related to the completion of other projects, the approval of a government regulation, or the opening of a shipping season. Even though such activities are not actually under the control of the project team, these activities — as well as milestones — may appear on the project schedule so that the project manager can properly sequence the project activities.

The net result is that the schedule may contain activities and milestones that are not integrally part of the project scope or WBS, and in turn, the WBS may contain work items that do not really belong in the budget.

Another fundamental difficulty with linking the cost and time baselines stems from the fact that time and cost are essentially different dimensions. Costs accumulate due to authorized work, and money as a resource can be applied only once to a specific activity. Time does not accumulate — it passes regardless of activities, and time as a resource can be applied to many activities simultaneously.

Applying the WBS to Both Budget and Schedule

Given all of these difficulties, why would anyone want to use a single framework, such as the WBS, to organise both cost and time? The WBS is appealing because it offers an elegant solution and a one-size-fits-all systems approach: simply create a WBS and use it for whatever project management needs may surface. Organise the budget to the WBS. Plan the schedule according to the WBS. Perform risk identification with the WBS. It is a very attractive approach, but does it work?

A prime reason for using the WBS to organise both cost and time is that doing so improves the chance that the budget and schedule will cover all of the same activities. Certainly, it could prove disastrous to include in the budget authorised work that does not appear on the schedule. It is not essential, however, to use a single WBS to ensure that both the budget and the schedule cover the same scope of work.

I recommend a budget-schedule linking technique that achieves the same objectives as using the WBS to organise both cost and time. My proposed technique, however, avoids the WBS's common difficulties while providing organisations with added flexibility. The first step is to completely identify and organise the scope through the WBS, then use the WBS to organise the schedule. Secondly, use corporate or industry cost codes to organise the budget. The third step is to link the schedule to the budget by recording only the cost codes for each related activity in the schedule. Organisations can compare the schedule with the budget by converting the schedule into a spreadsheet or database table and by sorting the activities by cost code. In this way, organisations can verify that each activity relates to one of the budget's specific cost categories.

Separating the management of a project's cost and time is not revolutionary; it is frequently performed by project managers who are unaware that they should use the WBS for both purposes or who believe that a common WBS is too difficult to use. The key contribution here is two fold: to recognise the logic of separating the two and to identify a process for ensuring that both are aligned with the scope description as it is detailed in the WBS.

Although a discussion focusing on the relative contents of the schedule, WBS and budget is interesting on its own, it is particularly relevant to the simplification and enhancement of earned value as proposed in this paper.

EVM Time Performance Challenges

Schedule Performance Units

In standard EVM methodology, the schedule variance compares the value of current performance to the value of planned achievement in relation to a specific point in time. Both measures are expressed in the same units as the budget (usually money or staff-hours). As a result, EVM schedule analysis will lead project managers to advise the sponsor or client, "The project is $40,000 behind schedule." This message is counter-intuitive: Executives are more likely to expect project managers to communicate schedule status in units of time, conveyed through statements such as "The project is running 15 days late." Figure 1 illustrates this difference. What is missing is an expression of the schedule variance in days, hours, or other appropriate unit of time.

Lipke (2003), among others, has recommended a new approach — Earned Schedule — that expresses schedule variance in units of time (SV(t)). This approach has its merits, but it also adds complexity to EVM, a technique that already challenges many.

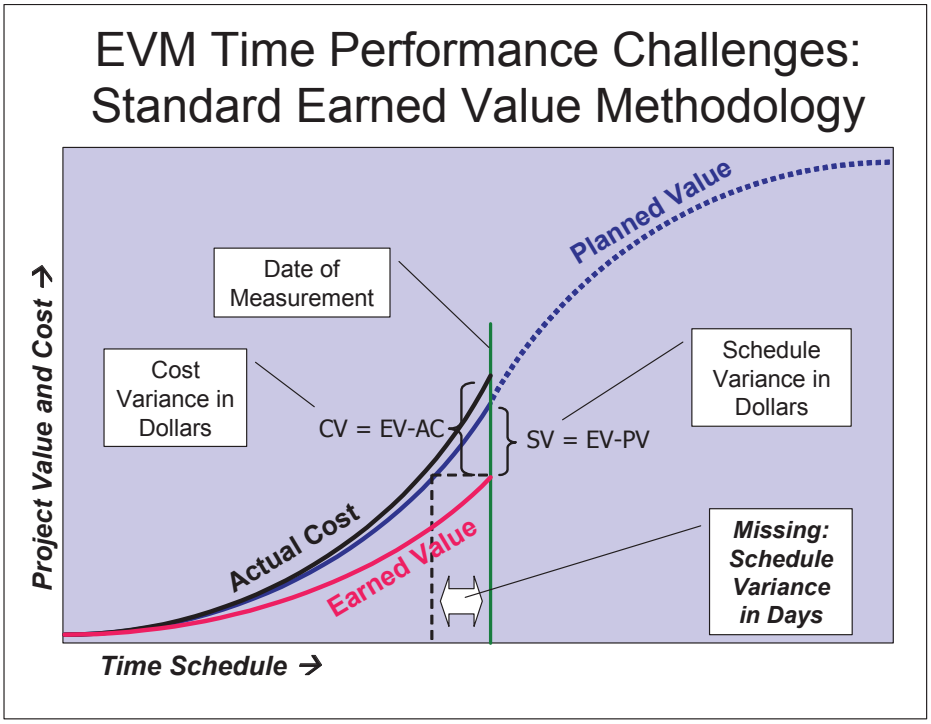

FIGURE 1. EVM TIME PERFORMANCE CHALLENGES.

Schedule Performance Anomaly

EVM has a well-known deficiency in its treatment of schedule performance. Since the schedule variance (SV) and the schedule performance index (SPI) are calculated using earned value (EV) and planned value (PV), as the project nears completion (typically in the final third) SV and SPI will indicate dramatic improvement. This is because EV always gradually approaches PV, and as the project nears completion, SV will move toward zero and SPI will move toward 1.0, indicating on-time performance, even for a project that was significantly delayed.

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Schedule Milestone Tracking

When organisations implement EVM, they measure performance on a regular basis, typically biweekly or monthly, but they are not measuring performance in relation to key project milestones, such as phase gates. Unfortunately, phase gates do not typically occur on a regular basis, such as monthly, and even if organisations measure EVM at both a phase's planned and actual end, they would find it difficult — maybe even impossible — to identify a particular phase's actual versus planned performance. This difficulty is because the cost information for a particular phase is not isolated when using standard EVM: All project costs are totalled together. Performance information about the phase nearing completion is mixed with data on the next phase, which is then already underway (Figure 2).

It is a given among project management researchers and practitioners that project managers can divide projects into phases to provide better management control. PMI (PMI, 2004) defined a project phase as "A collection of logically related project activities, usually culminating in the completion of a major deliverable. Project phases … are mainly completed sequentially, but can overlap in some project situations" (pp. 369–370). The transition from one phase to another within a project's life cycle typically involves some form of technical transfer or handoff. At phase end, project managers and clients often review the interim deliverables for completeness and accuracy, before allowing work to begin on the next phase.

A project phase typically ends when the management reviews the suitability of the phase's deliverables, the project's timeframe in relation to its schedule, and the costs expended and the resources consumed to achieve these results. Phase-end reviews are also called phase exits and phase gates. They are also called kill points because the organisation may decide, at this point, to cancel the project if its results prove unacceptable in relation to the actual cost incurred or the schedule status.

When phases are implemented sequentially, the phase review occurs with the project in a state of hiatus. No major project activities are in progress, which is an ideal point to calculate earned value.

Overlapping phase implementation is a method for fast-tracking projects, one that enables project teams to expedite the project or take advantage of available resources. When fast-tracking, project teams will start a new phase while completing work on a previous phase. This method is only possible when the in-progress activities of the previous phase do not limit the team's ability to implement the next phase. From an earned value perspective, those activities at the start of the new phase are not highly significant because they are very early in the context of that phase.

Regardless of whether phases overlap or occur in sequence, the end of a phase typically represents a critical path convergence point. On a network diagram, the project's dependences converge on the event or milestone representing the completion of that phase.

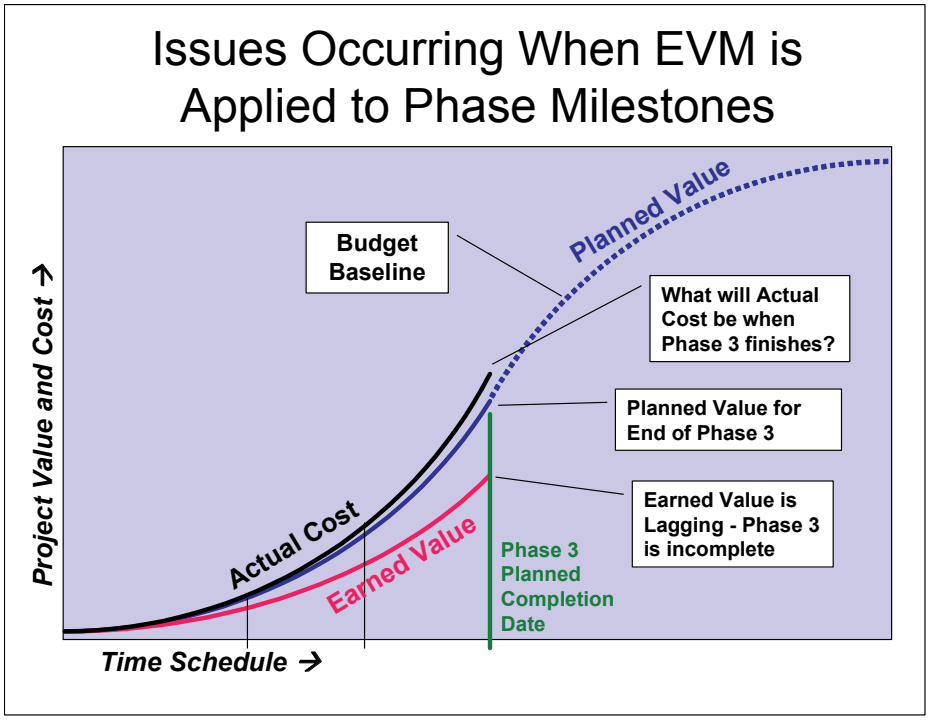

FIGURE 2. FIGURE 2. APPLYING EVM TO PHASE MILESTONES.

EVM Forecasting Challenges

Plotting future EV & AC trend lines

EVM typically plots the budget baseline as an S-curve from project initiation to completion. Proj-

ect managers can plot cumulative EV and AC values for all measurements to date. EVM alone cannot help project managers plot the expected future trend line of EV and AC to its end point. This is because of two reasons. First, the values plotted to date might not prove sufficiently consistent to allow extrapolation with any statistical validity. Second, the end dates for the EV and AC curves cannot be reliably determined from the current data. As noted above, the standard SPI value is faulty. Figure 3 illustrates this difficulty.

The PEVA Concept

Increasing the adoption of earned value

As noted earlier, EVM is most widely and intensively used in the US defence and aerospace industries and related areas, including US government agencies and military branches. Those practitioners who recognise the utility and reliability of using EVM often lament how slowly other industries are to adopt it, where its use has been entirely voluntary.

The current push in promoting EVM reflects a growing interest in standardising EVM and in maturing the field's practice of it. PMI has attempted to standardise EVM through publishing successive versions of its *PMBOK® Guide* and newer manuals, such as its *PS-EVM* (PMI, 2005). Many US government agencies—including the US DoD and the National Aeronautics and Space Administration (NASA)—have adopted EVM standards similar to PMI's. While this seems an enlightened course, it may also discourage practitioners from enhancing and improving EVM.

I recommend a significantly different approach toward promoting project performance management, one that also acknowledges the value of professional standards and shared definitions and nomenclature. The PEVA approach begins with acknowledging and addressing the known challenges of EVM, such as the complexities of an integrated baseline, the difficulties in evaluating incomplete work packages, the shortcomings of schedule variance and SPI, and the incapability to chart trend lines for future portions of the project, among others. The PEVA approach also determines whether project managers can significantly improve EV by incorpo-

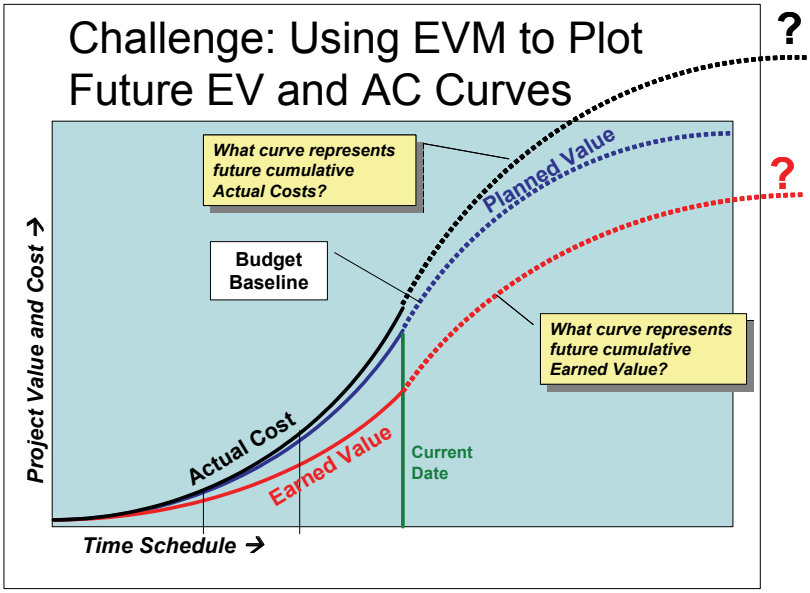

FIGURE 3. CHALLENGE — USING EVM TO PLOT FUTURE CURVES.

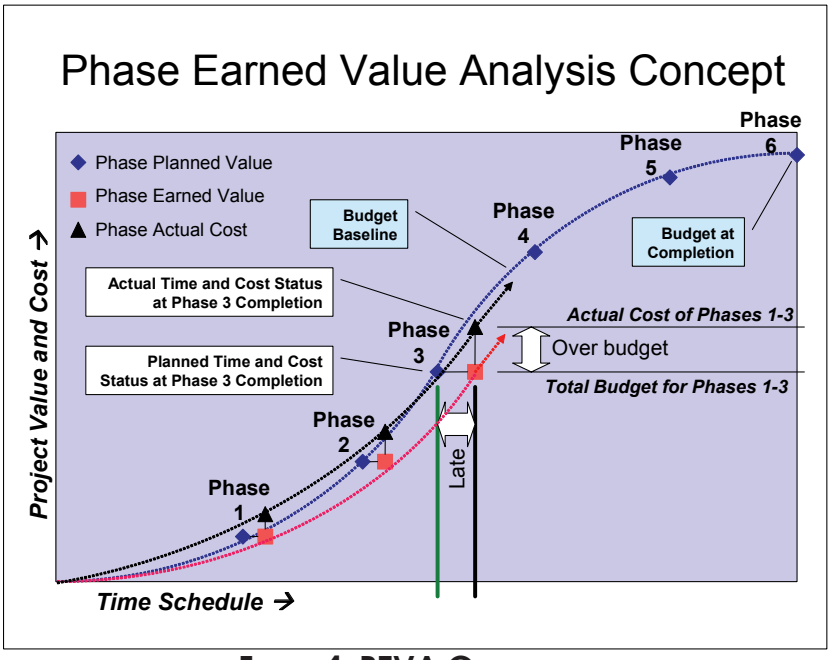

FIGURE 4. PEVA CONCEPT.

rating emerging project management concepts, such as ES and project phasing. The PEVA approach additionally enables managers to simplify their EVM calculations and demonstrate to executives its value by using improved illustrations showing project progress and achievement through graphic charting and trend depictions.

In short, the PEVA concept will not only help project managers address many of conventional EVM's shortcomings but also give them easier-to-use applications with additional features (Figure 4).

PEVA Concept Elements

Recognition of Structured Phases

With PEVA, structured phases are a key mechanism for controlling scope, time, and cost. Phases are logical components of the entire project. These naturally divide the entire scope into blocks of activities that often converge at a significant and defined completion point. The end of a phase provides organisations with a vantage point for reviewing the team's achievements in relation to the costs incurred and the time elapsed. EVM enables organisations to perform performance assessments at the end of a phase, but it does not isolate that phase's work from the work completed in other phases.

Separation of Time and Cost Baselines

PEVA allows organisations to prepare — and separately finalise — cost and time baselines that are each organised in relation to the specific demands of controlling expenses and schedules. The only requirements are that organisations use these to address all of the project work and that organisations adopt the phases as the primary divisions of both budget and schedule. PEVA does not prevent or forbid the integration of the cost and time baselines; it just does not require it. In contrast, EVM requires that organisations use a common WBS and create control accounts with identified costs, time frame, and responsible groups.

Simplify PV and EV Calculations

PEVA establishes the PV for each project phase by summing the budgets for all work taking place in that phase. Once the phase is complete, the EV equals the phase's PV. This equation is much simpler than EVM, which requires complex calculations based on the individual PVs for each control account as well as estimates of progress for those cost accounts that are not completed by a specific date. PEVA does not prevent organisations from calculating PV and EV for work packages that are in progress and for tracking and scrutinising work of specific vendors or departments.

Simplify Actual Cost Calculations

Using PEVA, organisations can calculate the Actual Cost (AC) of each phase by summing the expenditures or staff time reported for all of the work that has been completed in that phase. Only the costs (or man hours) reported by the contributing groups (departments or vendors) are tallied. This process is simpler than EVM, which requires organisations to attribute AC to every control account. Again, this is possible using PEVA, if an organisation desires to do so for control purposes; with PEVA, this is an option not a requirement.

Compares Planned with Actual Dates

With PEVA, organisations can note the planned completion date for each phase and compare this date with the actual date their team completes the phase. PV is associated with the planned phase completion date; EV and AC are associated with the actual completion date. This method uses the Earned Schedule concept recently introduced by Lipke (2003) and validated by Henderson (2003) in relation to conventional EVM. The PEVA method simplifies the Earned Schedule recognition by focusing on the phase completion milestone, as opposed to calculating the Earned Schedule for every control account that is underway or completed.

Forecasts Future Phase End Dates and Cumulative Costs

When a phase is completed, project managers can use PEVA to calculate the cumulative SPI(t). That progress index can help them to forecast the end dates of the following phases. The planned number of days from project start to the end of any unfinished phase (n) is multiplied by the last calculated SPI(t), which forecasts the number of days from the project start to the end of phase (n). With this approach, managers can plot the expected dates for all future Phase EV and Phase AC amounts, including those for the project completion.

In addition, for each completed phase, project managers can calculate the cumulative CPI at that point. That performance index allows them to forecast the cumulative actual costs of the following phases. The planned cost (PV) from project start to the end of any unfinished phase (n) is multiplied times the last calculated cumulative CPI. This forecasts the cumulative AC from project start to the end of phase (n). Therefore, managers can plot the expected values of future Phase EV and Phase AC, including those involving project completion.

PEVA Conditions

A project phase might be completed early, on-time, or late. A phase's AC may total less than, equal to, or more than the budget. Combining these potential outcomes produces nine possible conditions. Figure 5 depicts these conditions as they might appear on a PEVA Chart. Note that the cumulative EV (square) indicator is always at the same resource value on the X-axis as the cumulative PV (diamond) indicator; the cumulative AC (triangle) is always on the same point on the Y-axis as cumulative EV. For simplicity, I indicated the trend line for the PV only. Project managers using PEVA, however, can plot the EV and the AC trend lines as well.

PEVA Components

Organisations can implement PEVA using tools and components that are readily available to project managers. The first tool is the project time schedule. Project managers create and maintain these by using currently available or mandated project management software systems. They can structure the time schedule by using an already-established WBS or by creating a WBS format. Either way, the primary (level one) WBS is organised by project phases.

The second component is the PEVA Tracking Table, typically a spreadsheet that lists and totals the budget amounts and actual costs by project phase and also tracks the planned and actual phase completion dates. The PEVA Tracking Table may be a single budget and cost tracking worksheet for the project, or it may be the summary worksheet that brings together the budget and actual cost totals from individual worksheets set up for each project phase.

The PEVA Cumulative Summary Table uses the budget and actual cost information for each phase in the PEVA Tracking Table and presents it in a cumulative format. It also provides the planned and actual phase completion dates, transferred from the project

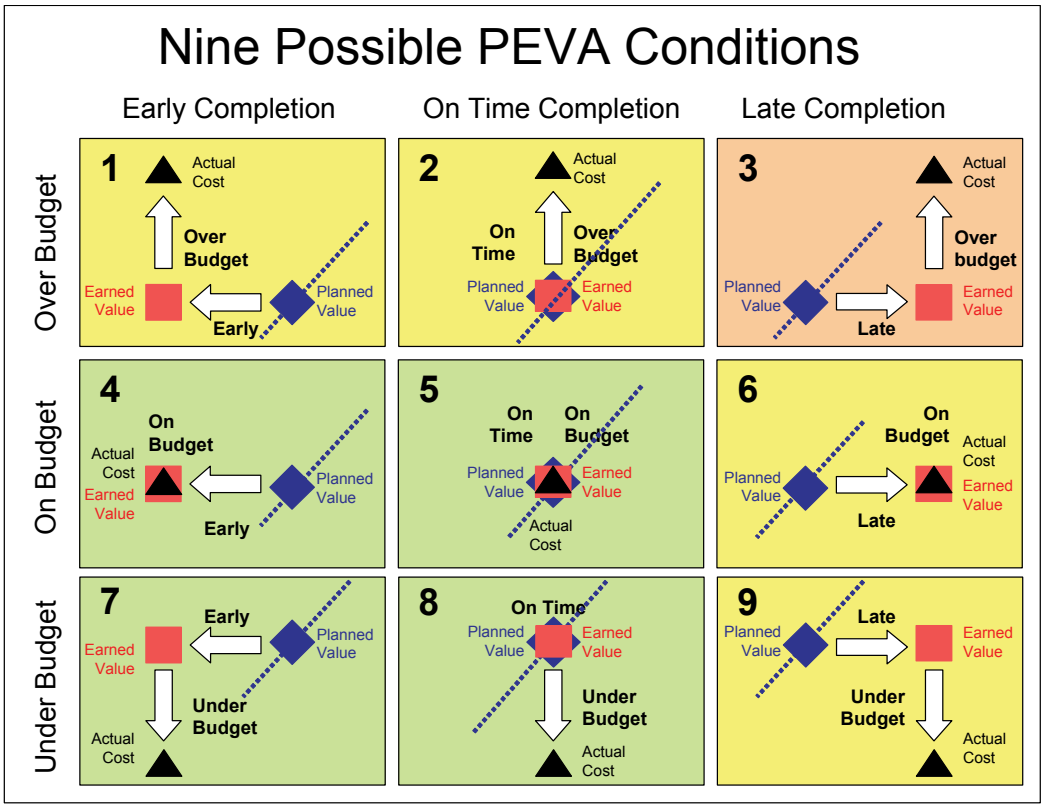

FIGURE 5. NINE POSSIBLE PEVA CONDITIONS.

schedule. The PEVA Cumulative Summary Table enables project managers to calculate the cumulative CPI and SPI(t) and to forecast both the future AC values and the expected completion dates for all remaining unfinished phases.

The PEVA Trend Chart lists the PEVA data in a graphic format. In its simplest form, this chart could take the form of a spreadsheet file, linked to the PEVA Cumulative Summary Table. As there are two date ranges (the planned and the actual phase end dates), organisations should set up this chart as a scatter diagram so as to effectively show the trend lines.

Implementing PEVA

I recommend using these sequential steps when implementing PEVA.

1. **Prepare time schedule by phases.** Even a project with a minimal amount of planning will have a basic time schedule, often in the form of a Gantt chart that project managers can readily prepare using common project management software packages. While a schedule may list various major groupings of activities, project managers commonly use a primary division (i.e., the first level of the WBS) to structure the implementation phases. These phases can overlap or occur sequentially; these are typically arranged in order of phase completion. The number of phases is determined by the specifics of each project and can vary from a few phases for small projects to hundreds of phases for large projects involving multiple project locations or iterations.
2. **Prepare budget by cost elements.** This is the preferred way to prepare a budget for PEVA. Project managers identify the sources of cost in terms of the groups that charge the project, either as expenses or staff hours. For external costs, project managers should obtain firm quotes or reasonable estimates from each consultant or supplier to the project. For internal costs, they should obtain from the participating internal departments a firm estimate or commitment of staff hours they will charge to the project. These estimates or quotes, once approved by senior management, represent the approved budget. Project managers will need to convert to this format any estimates prepared by other methods, such as through parametric models or elemental breakdowns (as in construction estimating).
3. **Group budget elements by phase.** The budget may initially be arranged according to the estimating format, the order of the cost codes, or many other possible formats. When using PEVA, project managers must rearrange their budget elements on the PEVA table in relation to the project phases in which these elements occur. They should then divide any cost elements occurring in more than one phase. This will ensure that they will estimate or calculate costs for that element separately for each phase on the PEVA table. Although a consultant contract will state the total fees payable, such contracts also frequently indicate how that fee is calculated or billed according to project phase. Managers can attribute single-order vendor deliverables to specific phases. For example, project managers can establish — for each phase — the cost of installing air conditioning units over multiple phases of a construction project. To calculate these costs, total up all of the budget costs within each phase on the PEVA table and tally the total project budget.
4. **Confirm activities and transfer phase completion dates.** Ensure that each of the activities on the Gantt chart for a given phase is covered by a contributing group listed in the PEVA table for that same phase. Project managers can confirm this item by inserting a column in the Gantt chart titled “Cost Code” in which they record the budget cost code for that activity. They can also track this item by using the Resource column and naming the responsible group. Confirm the duration of all activities, especially those on the critical path. Transfer the completion date for each phase from the Gantt chart to the PEVA table.
5. **Deal with approved changes.** Make changes to the Gantt chart or PEVA table as the project progresses and ensure that all added activities involving the contributing groups are detailed in formal arrangements, such as change orders and purchase orders. Project managers may readily add to the project any activities with no cost impact (e.g., board meetings). They can also reschedule activities within any given phase, as re-

quired, and move resources from one activity to another on the Gantt chart, without concern for cost impact—as long as the contributing groups do not claim added charges or staff hours. Project managers can also add additional approved costs (e.g., more expensive equipment) to the budget (normally as a separate line item) without adding a corresponding work package to the WBS and schedule, as long as the original activities match the revised work item.

6. **Track progress and completion.** As each activity is implemented, estimate its progress and record the percentage of completed value on the Gantt chart. Project managers can use project management software to perform this activity because the current software automatically calculates the percentage complete. If desired, project managers can update the PEVA table with additional information. The key information, however, is achieving 100% completion for each phase. As each phase is completed, enter the actual completion date on the PEVA table.
7. **Tally actual costs.** Calculate the actual costs for the work performed and deliverables provided by the contributing groups (departments, vendors). Perform this activity in the same manner as conventional EVM. However, it is not necessary to sub-divide all costs to the level of control accounts. For internal staff, it is only necessary to determine the work hours claimed by all personnel assigned to each project phase; it is not necessary to attribute staff hours to each work package or control account. For vendors and consultants, it is only necessary to determine the project costs claimed by each firm for that phase. Actual staff-hours and billed costs will include fees and charges for all approved changes, but it is not necessary to attribute those to specific changes. Project managers can track AC on a separate spreadsheet or by using sophisticated cost control system. Enter the actual costs for each contributing group on the PEVA table and calculate the total AC for that phase.
8. **Review variances and take action.** Entering 100% completion for a phase, the phase completion date and the actual cost of that phase will cause the PEVA Summary Table to automatically calculate the CV, CPI, SV(t) and SPI(t) for that phase, and also to forecast the cost and schedule variances and indices for the balance of the project. Project managers can review these indicators and take necessary actions to address any cost overruns or schedule slippage issues.

PEVA Cost and Time Calculations

Calculating PEVA is very similar to calculating EVM, but there are several simplifications and a few key differences. The following are specified PEVA's cost and time measures, variances, and indices.

PEVA Cost Measures and Indicators

Phase Planned Value [PVp] is the total budget for a phase.

Phase Earned Value [EVp] is equal to the Phase Planned Value, once the phase is completed.

Phase Actual Cost [ACp] is the total of all internal and external costs attributed to that phase.

Phase Cost Variance [CVp] is the difference between Phase Earned Value and Phase Actual Cost.
CVp = EVp – ACp

Phase Cost Performance Index [CPIp] is Phase Earned Value divided by Phase Actual Cost.
CPIp = EVp/ACp

Cumulative Cost Variance [CVcum] is total EV less the total AC, for all completed phases.
CVcum = EVcum – ACcum

Cumulative CPI [CPIcum] is the total EV divided by the total AC, for all completed phases.
CPIcum = EVcum / ACcum

PEVA Time Measures and Indicators

Project Start Date is the planned and actual date for the initiation of the project.

Phase Planned Completion Date is the calendar date (or time) on which the phase is planned to finish.

Phase Actual Completion Date is the point when the phase deliverables are accepted as 100% complete.

Phase Schedule Variance [SV(t)] is the difference between Planned and Actual Completion Dates for that phase.

Cumulative Schedule Performance Index [SPI(t)] is the current planned duration (days), divided by the current actual duration, both counted from the project start to the end of the last completed phase.

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Forecast Phase End Date is the planned duration from the project start to the end of an incomplete phase, multiplied by the cumulative SPI(t) for the last completed phase.

Sample PEVA Project

Implementing PEVA is best illustrated by analysing a simple project. To minimise this effort, I have limited the number of sample project's phases and its budget elements to the minimum necessary to explain PEVA. Appendix 1 shows the PEVA calculations and chart as these would appear at the end of Phase 2. The Gantt chart is not shown due to space limitations and because the time schedule is relevant to PEVA only for identifying each phase's planned and actual completion dates.

PEVA Tracking Table

The tracking table serves as the entry point for calculating key budget and expenditure amounts during project planning and implementation. The project is divided into the desired number of phases, and the budget for each phase is subdivided according to the contributing groups and not necessarily by work packages or control accounts.

The project manager enters AC per department or vendor as these are accumulate and enters the completion date after the project team has completed all phase activities on the time schedule and the owner accepts these. The table then shows that EV per phase is equal to PV; it then totals AC per phase. CV and CPI are automatically calculated per phase. Since EV is equal to the PV at the end of every phase, there is no point in calculating the conventional SV and SPI for each phase because these will always total zero and 1.0, respectively.

In the sample project, the project team has completed phases one and two. The AC for these phases were entered along with the completion dates for those phases. At this point the Total Cost Variance is $3,600 and the CPI is 1.14 overall.

PEVA Cumulative Performance Forecast

This table contains the phase end dates, summarises the cumulative costs, and generates cost and time forecasts. Once the schedule is approved, the manager enters the target completion dates for each phase in the "Planned End Date" column. The "Forecast or Actual End Date" column gives the actual end date for that phase if one

has been entered in the Tracking Table. The Cumulative Performance Forecast table uses the planned and actual dates to instantly generate the SV(t) and Cumulative SPI(t) values for that phase. The built-in formula then uses that SPI(t) value to calculate the Estimated End Date at the far right of that row. If the phase has not been completed, then the table formula uses the last calculated Cumulative SPI(t) value to forecast the end date for that phase as well as all remaining phases. In the sample, the Cumulative SPI(t) of 0.95 results in an Estimated End Date that is 10 days late.

If a phase has been completed, PEVA uses its PV, EV, and AC (from the Cost Table) to automatically calculate the Cumulative CV and CPI and to forecast — using the standard formula EAC = BAC / CPI — an Estimate at Completion for the project. If a phase is incomplete, PEVA uses the last calculated Cumulative CPI to forecast Actual Cost for that phase and all remaining phases. In the sample, the Cum CPI of 1.14 results in an EAC of $150,648.

Phase Earned Value Analysis Chart

These cumulative values for PV, EV, and AC, as well as the associated dates, generate the three sets of points on the PEVA Chart. Note that a conventional EVM baseline chart will show these three values at the same date and therefore, as vertically aligned. PEVA illustrates these values on the dates these occur, clearly demonstrating — graphically — the Phase SV(t) by the horizontal time delay between PV and EV and the Phase CV by the vertical cost difference between EV and AC. These characteristics make the PEVA Chart much easier to comprehend and explain than a conventional EVM baseline chart, features which may encourage project professionals to accept, appreciate, and adopt the earned value approach in their organisations.

The Forecast End Dates and the Forecast Actual Cost values for incomplete phases permit PEVA to plot those future points and to join them graphically, indicating these expected trends.

Conclusions

PEVA, as introduced in this paper, represents a promising variant on conventional EVM methodology, one that may prove particularly attractive to project managers who wish to implement earned value performance measurement without the inherent demands of an integrated cost/time baseline. As the name implies, PEVA focuses on performance at the end of each phase, an appropriate point for assessing and reporting project results. PEVA also provides features not found in standard EVM, features including the improved calculation and presentation of schedule variance on the basis of actual days early or late and the ability to forecast and chart both the cost and dates for the completion of future phase milestones.

To substantiate PEVA, organisations will need to use it while implementing projects of varying scale in diverse industries. Only through this way can the field demonstrate PEVA's effectiveness and identify the areas that may require improvement. However, the simple example provided in this paper clearly demonstrates the feasibility of using the concept.

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Appendix 1. PEVA Sample

Phase Earned Value Analysis Sample Project

PEVA Tracking Table

Phase No.	Phase and Budget Item	Date Phase Completed	Planned Value PV	Earned Value EV	Actual Cost AC	Cost Variance CV	Cost Perf. CPI
1	**Planning Phase**	**2005-01-17**	**14,000**	**14,000**	**12,500**	**1,500**	**1.12**
101	Design Dept.		8,000		7,000		
102	Marketing Consultant		6,000		5,500		
2	**Development**	**2005-02-12**	**15,000**	**15,000**	**12,900**	**2,100**	**1.16**
201	Engineering Dept.		13,000		11,000		
202	Prototype Vendor		2,000		1,900		
3	**Implementation**		**59,000**	**0**	**0**	**0**	**0.00**
301	Engineering Dept.		30,000				
302	Fabrication		24,000				
303	Assembly		5,000				
4	**Installation**		**35,000**	**0**	**0**	**0**	**0.00**
401	Contracts Dept.		21,000				
402	General Contractor		14,000				
5	**Testing**		**23,000**	**0**	**0**	**0**	**0.00**
501	Test Consultant		13,000				
502	Test Materials		10,000				
6	**Commissioning**		**26,000**	**0**	**0**	**0**	**0.00**
601	Engineering		15,000				
602	Training		11,000				
Totals			**172,000**	**29,000**	**25,400**	**3,600**	**1.14**

PEVA Cumulative Performance Forecast

Phase	Planned End Date	Forecast or Actual End	Planned Value	Earned Value	Actual Cost	Cumul. CV	Cumul. CPI	Cumul. EAC	Phase SV(t)	Cumul. SPI(t)	Est. End Date
Start	2005-01-01		0	0	0	0					
1	2005-01-15	2005-01-17	14,000	14,000	12,500	1,500	1.12	153,571	-2	0.88	2005-09-01
2	2005-02-10	2005-02-12	29,000	29,000	25,400	3,600	1.14	150,648	-2	0.95	2005-08-12
3	2005-04-01	2005-04-05	88,000	88,000	77,076	10,924	1.14	150,648	-5	0.95	2005-08-12
4	2005-06-10	2005-06-18	123,000	123,000	107,731	15,269	1.14	150,648	-8	0.95	2005-08-12
5	2005-07-11	2005-07-20	146,000	146,000	127,876	18,124	1.14	150,648	-10	0.95	2005-08-12
6	2005-08-02	2005-08-12	172,000	172,000	150,648	21,352	1.14	150,648	-11	0.95	2005-08-12