AS 4817—2003

Project performance measurement using Earned Value

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Australian Standard™

Project performance measurement using Earned Value

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PREFACE

This Standard was prepared by the Standards Australia Committee OB-014, Earned Value Performance Measurement.

The terminology used in this Standard has been chosen to be acceptable across a wide range of disciplines. Terms used in the Standard that are in common use have been adopted from the *PMBOK Guide 2000 Edition*. If the PMBOK did not provide an adequate definition of a term then the definition from ANSI EIA-748, *Industry Guidelines for Earned Value* was used. In some cases slight alterations have been made to the definitions to better reflect the Australian context. If neither the PMBOK nor ANSI EIA-748 provided a satisfactory definition for a given term then the Committee created an applicable definition.

If terms have a common-use abbreviation then this abbreviation has been used, subsequent to its first use, throughout the remainder of the Standard.

The terms 'normative' and 'informative' have been used to distinguish between prescriptive and non-prescriptive parts in the Standard respectively. The 'normative' parts are the sub-sections in Section 3 titled 'Requirements' and Annex A containing the Glossary. Parts of the Standard that are 'informative' include those marked 'informative' and titled 'Guidance'. Where a term from the Glossary is used in an 'informative' part of the Standard it is not intended that the term impart 'normativity' to that part.

Terms that are defined in Annex A are set in SMALL CAPITALS throughout this Standard.

The objectives of this Standard are:

- To define the essential elements of the EVPM method.
- To provide enough information about how to implement the method to allow the user to gain the benefits of the method.
- To be used as a measurement tool to determine whether the EVPM method has been implemented.
- To provide a basis for EVPM implementation for all industries and sizes of Projects.
- To clearly communicate the benefits of the EVPM method.
- To be fundamentally compatible with any existing Australian or International Standards.
- To be relevant to Project Managers (PMs) and executive management in organisations that manage by Projects.

CONTENTS

FOREWORD

EARNED VALUE PERFORMANCE MEASUREMENT (EVPM) is a method for measuring and reporting PROJECT performance, and forecasting future performance based on past performance. The EVPM method measures performance of the time and cost aspects of a PROJECT and enables effective PROJECT MANAGEMENT.

The EVPM method provides:

- means for measuring PROJECT performance and status;
- means for measuring progress against a BASELINE (plan);
- forecasts of future performance based on past performance; and
- metrics for comparison of PROJECT performance across an organisation and between organisations.

EVPM assists managers to:

- report cost and schedule performance using standardised techniques;
- analyse variances between the plan and actual progress;
- CONTROL changes to the BASELINE; and
- forecast completion costs and FINISH DATES.

Section 1 INTRODUCTION

1.1 Scope

This Standard establishes requirements and gives guidance for the measurement and reporting of cost and schedule performance of PROJECTS and PROGRAMS using the EVPM method.

1.2 Application

This Standard MAY be applied to the measurement and reporting of the cost and schedule performance of PROJECTS and PROGRAMS. It MAY be applied to any situation where a specified DELIVERABLE (product, service, output, result) is to be produced by a specified date and with finite resources.

The method MAY be used for the performance measurement of single PROJECTS, for parts of PROJECTS (including contracted and sub-contracted parts), for PROGRAMS consisting of multiple PROJECTS, and for organisations that manage by PROJECTS.

In the multi-PROJECT environment, EVPM provides metrics for summary level reporting throughout the organisation. The metrics MAY be rolled up by output, by PROGRAM, by organisational unit, organisational objective, key performance indicator, or other organisation specific summarisation required for effective management reporting.

1.3 Definitions

For the purpose of this Standard, the definitions given in Annex A apply.

1.4 What is Earned Value?

One of the problems faced by managers, is to understand how much work has actually been performed and how much it has cost. Of greater concern to managers is the difficulty of estimating the final cost and completion date of the planned work, especially if the work is not running according to schedule.

This problem and the solutions provided by the EVPM method are illustrated in Figures 1.1 to 1.4 and the accompanying text. Figure 1.1 shows a graphical representation of a time-phased schedule. The BUDGET line represents the cumulative BUDGET for the work spread over time.

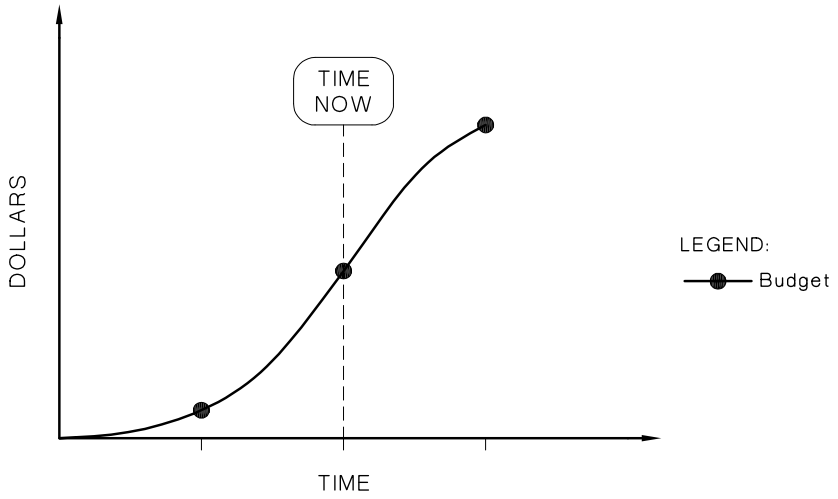


FIGURE 1.1 TIME PHASED BUDGET

Work does not necessarily run exactly to plan, so the manager needs to know how work is progressing compared with the plan. Many managers have access to the ACTUAL COSTS (AC) that have been incurred for their work. Figure 1.2 shows the cumulative AC for the work due to date.

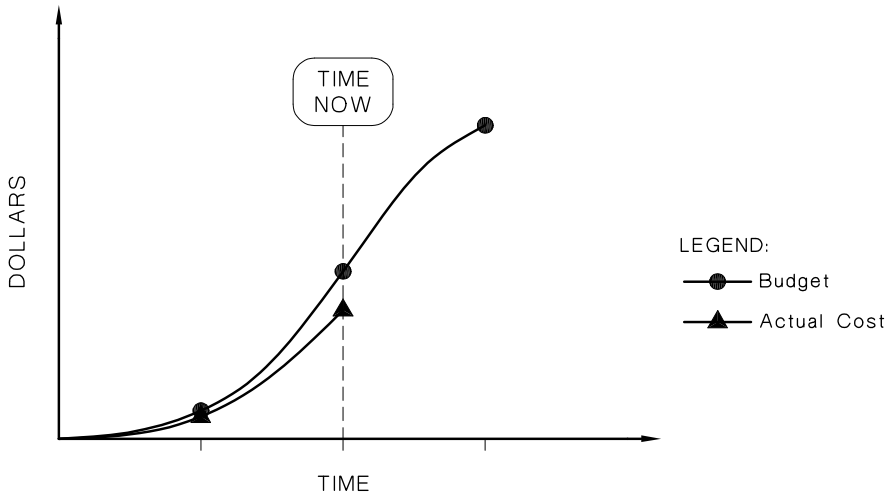


FIGURE 1.2 COMPARISON OF BUDGET AND ACTUAL COST

Figure 1.2 shows that the cost of the work at any point in time is running under BUDGET. This information by itself gives the impression that the work will be completed under BUDGET. However, the manager may only have a little understanding of how much work has actually been performed. The AC involved may have been on tasks outside the original SCOPE or it may have been spent inefficiently.

To overcome this problem, the manager needs a third item of information, which is known as the EARNED VALUE (EV). EV is the value of completed work expressed in terms of the BUDGET assigned for that work. Figure 1.3 shows the EV for the work completed to date.

Figure 1.3 puts the work performance in a different perspective. The EV is actually below the AC. This means the work is really running over cost. This is contrary to the impression given in Figure 1.2.

Figure 1.3 also shows the EV is below Budget, which means that the PROJECT is running behind schedule. This could not have been recognised from Figure 1.2.

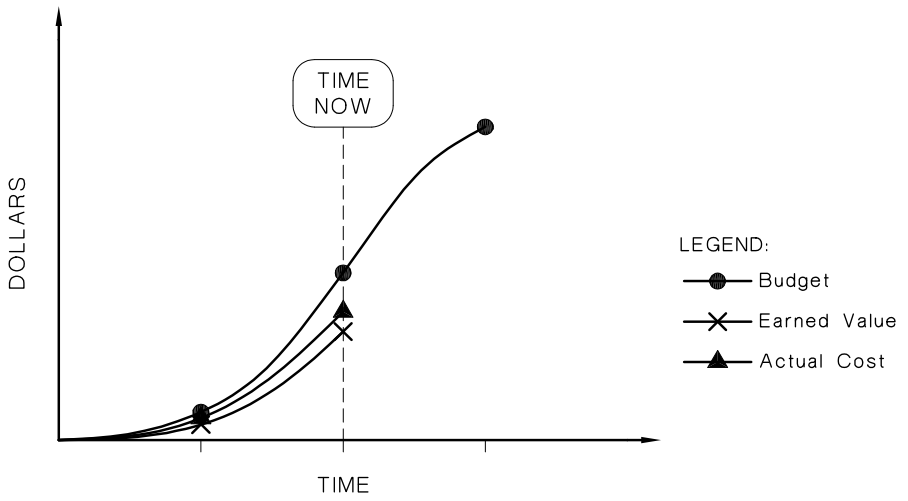


FIGURE 1.3 COMPARISON OF BUDGET, ACTUAL COSTS AND EARNED VALUE

This demonstrates the benefit of knowing the EV of the work in addition to the BUDGET and AC. This information is only available in a project management system utilising EVPM.

Managers need a reliable forecast of when the work will be completed and how much it will cost at completion. When the EV is available, the manager knows how much work has actually been performed. The eventual cost and completion date of the work can be forecast, as the original BUDGET is known, assuming efficiencies remain the same. The forecast can take into account past performance. Figure 1.4 shows a forecast for cost and completion for the PROJECT based on past performance.

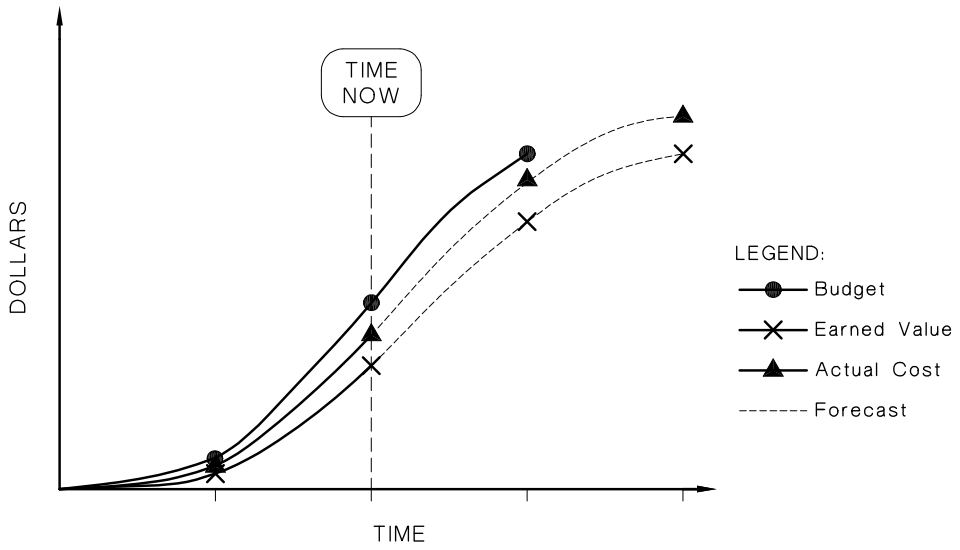


FIGURE 1.4 COMPARISON OF BUDGET, ACTUAL COST AND EARNED VALUE WITH FORECASTS BASED ON PAST PERFORMANCE

1.5 Benefits of Earned Value Performance Measurement

Direct and indirect benefits accrue from the focussed planning needed for implementation, objectivity in EVPM and the availability of robust data for future management decisions.

Specific benefits are:

- objective measurement of PROJECT performance in both cost and time;
- forecasting of future performance, completion date and cost at completion based on past performance;
- objective metrics for comparison of PROJECT performance across an organisation and between organisations;
- development of appropriate BUDGETS and BASELINES;
- compilation of appropriate estimates;
- ensures that percentage complete of WORK PACKAGES is consistently measured;
- focus on comparison between actual performance and budget;
- reinforces emphasis on disciplined change CONTROL; and
- immediate highlighting of inconsistencies in the above measures in EV reports.

Regular EV reporting provides a strong incentive to ensure consistency of the overall reporting and performance measurement framework.

Section 2 EARNED VALUE PERFORMANCE MEASUREMENT

This Section provides an introduction to, and examines the basic concepts of, EVPM using simple examples.

2.1 Basic Actions

EVPM requires that PMS:

- determine what work is to be done, by whom, and when;
- establish realistic resource requirements for the work;
- objectively measure work achievement and record associated costs;
- report any significant deviations from the plan;
- forecast the completion date and cost; and
- plan and implement CORRECTIVE ACTION plans and authorise SCOPE CHANGES.

EVPM requires that planning includes the establishment of clear objectives for achievement and demands that progress is monitored so as to measure any deviations from the plan. It encourages PMS to be objective in planning, assessment of progress, use of resources and forecasting of future progress.

2.2 Basic Concepts

2.2.1 *Implementation*

There are three keys to success in using EVPM:

a. Work SHOULD be planned in such a way that objective measurement of achievement is possible.

b. Objective techniques SHOULD be selected, in advance, to measure 'achievement' for each piece of work.

c. Cost, schedule and technical achievement aspects SHOULD be integrated in one management system i.e. cost and schedule SHOULD not be managed in isolation.

Setting up a PROJECT for EVPM requires a suitable decomposition of the work (as set out in Clause 3.1), establishment of a WORK BREAKDOWN STRUCTURE (WBS), identification of personnel to be assigned responsibility, scheduling of the work and assignment of resources to the work SCOPE.

At this point a slight variation is introduced to conventional planning. Objective methods, which will be used to determine whether work has been accomplished, are pre-planned. A BASELINE is established in the form of a time-phased BUDGET, showing planned expenditure for each element of work in a given time frame. This is known as PLANNED VALUE (PV) and can be plotted to produce the PERFORMANCE MEASUREMENT BASELINE (PMB) (refer to Figure 2.1).

2.2.2 *Example of EVPM*

A PROJECT is assigned a value of $3000. For simplicity, it is assumed that the PROJECT consists of three tasks namely *Outline*, *Draft* and *Review/Acceptance*. Each task is assigned a value of $1000 and is scheduled to occur over a three month period. Table 2.1 shows the BASELINE schedule for this PROJECT.

The tasks were completed as follows:

a. *Outline* – started on time in Month 1 and finished early in Month 1.

b. *Draft* – started early in Month 1 and finished late in Month 3 (vs a planned finish in Month 2).

c. *Review/Acceptance* – started late in Month 3 (vs a planned start in Month 2) and finished late in Month 4 (vs a planned finish in Month 3).

Table 2.1 shows the actual performance achieved with each of the tasks.

When the PROJECT is completed it is said that it earned the value of $3000 against the plan; or more simply EV = $3000. Note that the AC of the PROJECT is not required to determine EV as it is determined during the planning process. Tables 2.2 and 2.3 show the performance of the PROJECT.

As the PROJECT progresses, variances can be measured. COST VARIANCE (CV) and SCHEDULE VARIANCE (SV) for the PROJECT are depicted in Table 2.4.

As work progresses CV and SV can be measured from the plan in dollar terms. Thus deviations can be depicted from the plan as shown in Table 2.4 and Figure 2.1. Hence, there was a CV of +$300 at the end of Month 1, (i.e. AC was $300 less than the EV), and a SV of –$1000 at the end of Month 2 because *Draft* was not completed on schedule (i.e. EV was $1000 less than PV).

Notice that there was no credit for any partial completion of the *Draft* because the objective measure of performance in this case is completion of the *Draft* and this occurred in Month 3. However, costs were incurred during Month 2 because resources were being expended in progressing the *Draft* and recorded in the financial accounting system.

The requirement to measure performance obliged the user to plan objectively in advance. This allows the calculation of ACS and EV and hence has given quantification of CVS and SVS. From a management viewpoint the strength of the process is that it focuses on areas requiring attention by concentrating on the variances.

This example is simplistic and obviously a formal management CONTROL system would not be established for such a PROJECT in isolation. A real PROJECT would comprise many tasks occurring at the same time.

Month	1	2	3	4
Outline				
Draft				
Review and Acceptance				

Table 2.1 Baseline Schedule & Actual Schedule

Planned Value	1000	1000	1000	0
Earned Value	1000	0	1000	1000
Actual cost	700	700	300	850

Table 2.2 Monthly Performance

Planned Value	1000	2000	3000	3000
Earned Value	1000	1000	2000	3000
Actual Cost	700	1400	1700	2550

Table 2.3 Cumulative Performance

Cost Variance (EV-AC)	$300	−$400	$300	$450
Schedule Variance (EV-PV)	$0	−$1000	−$1000	$0

Table 2.4 Variances

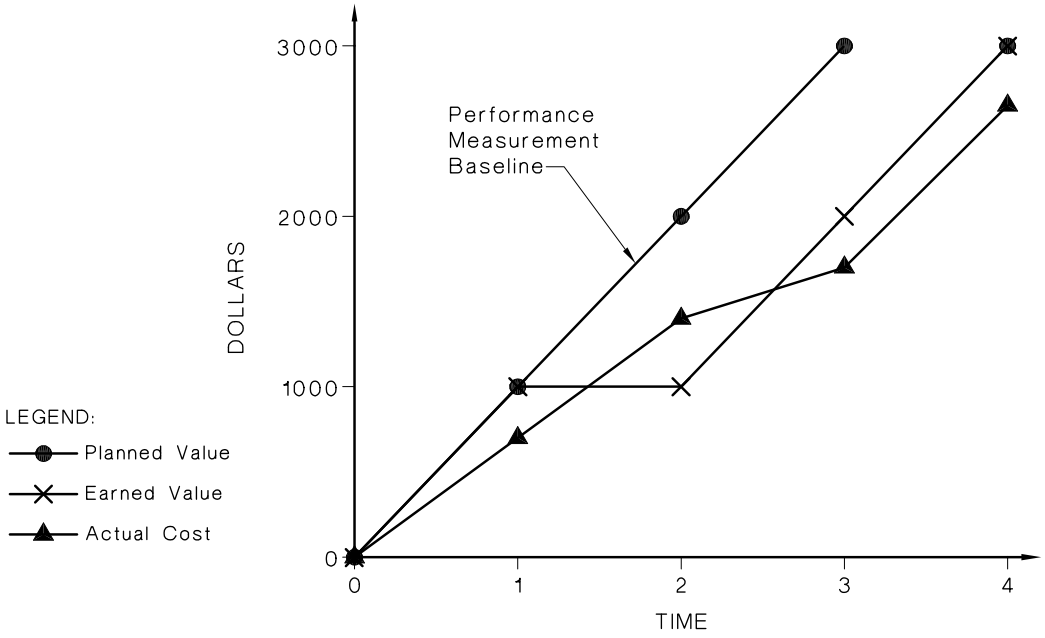


FIGURE 2.1 BASIC PERFORMANCE CHART

2.3 What About a More Complex Project?

2.3.1 *Example*

Consider a multi-activity PROJECT. The PROJECT is currently $50 000 under BUDGET and some ACTIVITIES are behind schedule, whilst other ACTIVITIES are ahead.

Without EV, the PM tends to concentrate on ACs compared to the BUDGET, however, the schedule is usually considered separately. EVPM would give the PM a better insight in the position of the PROJECT. Consider Scenario *A* and Scenario *B*, shown in Table 2.5 and Table 2.6 respectively.

Planned Value	$250000
Earned Value	$230000
Actual Cost	$200000
Schedule Variance	−$20000
Cost Variance	+$30000

Table 2.5 Scenario A

The summary of Scenario *A* gives a mixed picture. The AC situation is good (AC < EV) but the schedule is clearly not good (EV < PV).

Planned Value	$250000
Earned Value	$180000
Actual Cost	$200000
Schedule Variance	−$70000
Cost Variance	−$20000

Table 2.6 Scenario B

The summary of Scenario *B* yields only bad news. The PROJECT is running behind (EV < PV), and the work that has been done is overspent (AC > EV).

Given that the PM has this information, then the ESTIMATE AT COMPLETION (EAC) for the PROJECT (which is a critically important piece of information) can be refined.

2.3.2 *Estimate at Completion*

In neither case in Clause 2.3.1 does the PM yet know the impact of the SV on completion time. For this the PM needs to know the criticality of tasks which are behind schedule. However, in Scenario *A*, the PM does know that additional resources are needed to recover schedule, if necessary. This highlights the fact that EV does not constitute a total measurement process. Other techniques remain important, such as statused schedules and forecasts drawn from those schedules. But the existence of EV adds a new and important dimension that simplifies analysis of progress and provides critical management information.

One of the greatest benefits of EVPM is the ability to forecast objectively. That is, to use past performance to forecast future performance, cost at completion and, in conjunction with schedule analysis, the completion date.

The following charts (Figures 2.2 and 2.3) clarify the terms used and the method of using performance measurement information to forecast the completion date and cost at completion.

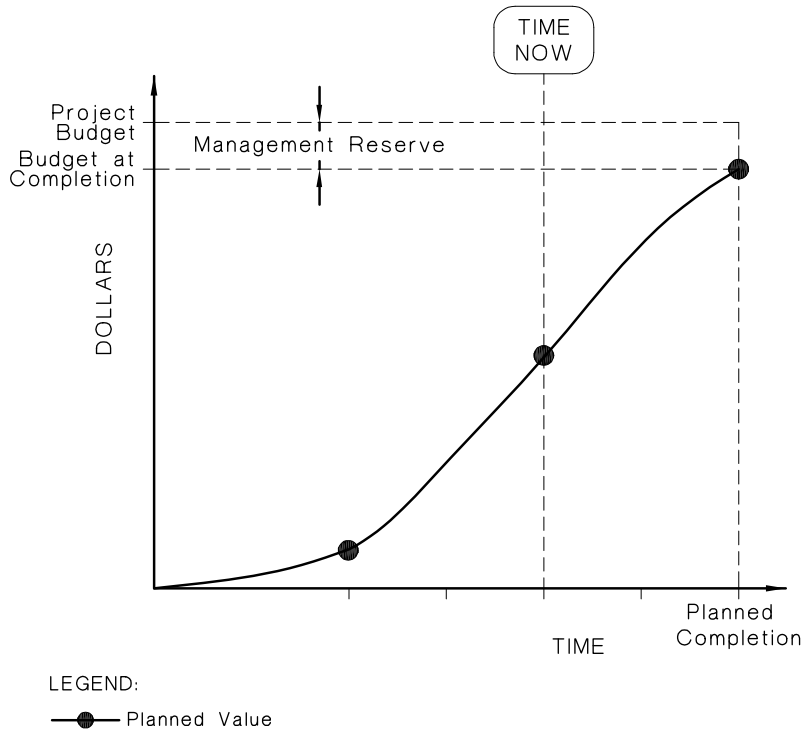


FIGURE 2.2 TIME PHASED BUDGET

Figure 2.2 shows the PMB and MANAGEMENT RESERVE.

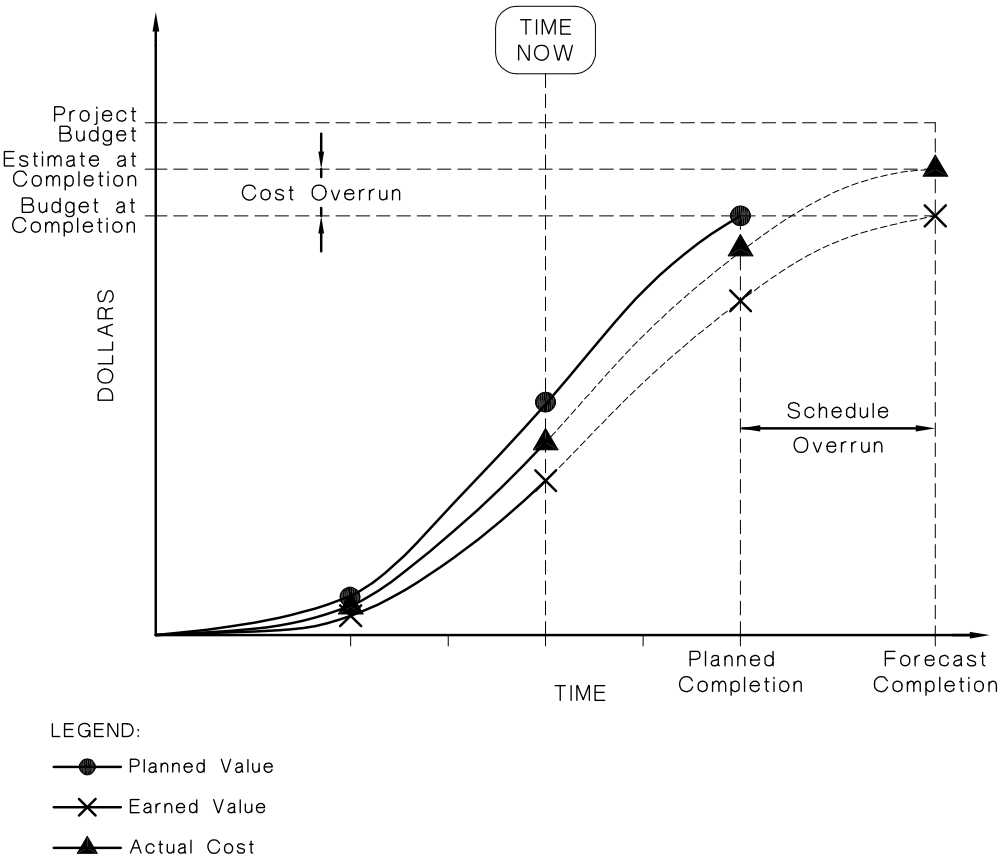


FIGURE 2.3 COMPARISON OF BUDGET, ACTUAL COST AND EARNED VALUE WITH FORECASTS BASED ON PAST PERFORMANCE

Figure 2.3 illustrates how past performance (i.e. before 'Time Now') is used to forecast the cost at completion and completion date. The trend of EV to date is extrapolated to BUDGET AT COMPLETION (BAC). This gives a forecast completion date (assuming that future performance will be similar to the past). The AC to date is projected to the forecast completion date. This gives the EAC assuming cost efficiency i.e. PV/AC continues at the same rate to the end of the PROJECT.

Annex B provides formulae to calculate EACs. Some commonly used formulae are provided which use different weightings of past cost and schedule performance.

Section 3 THE EARNED VALUE PERFORMANCE MEASUREMENT PROCESS

The steps in Figure 3.1 outline the process of applying the EVPM method to a PROJECT. Each step is expanded later in this Section with details of the specific requirements for compliance with each step, as well as notes for guidance.

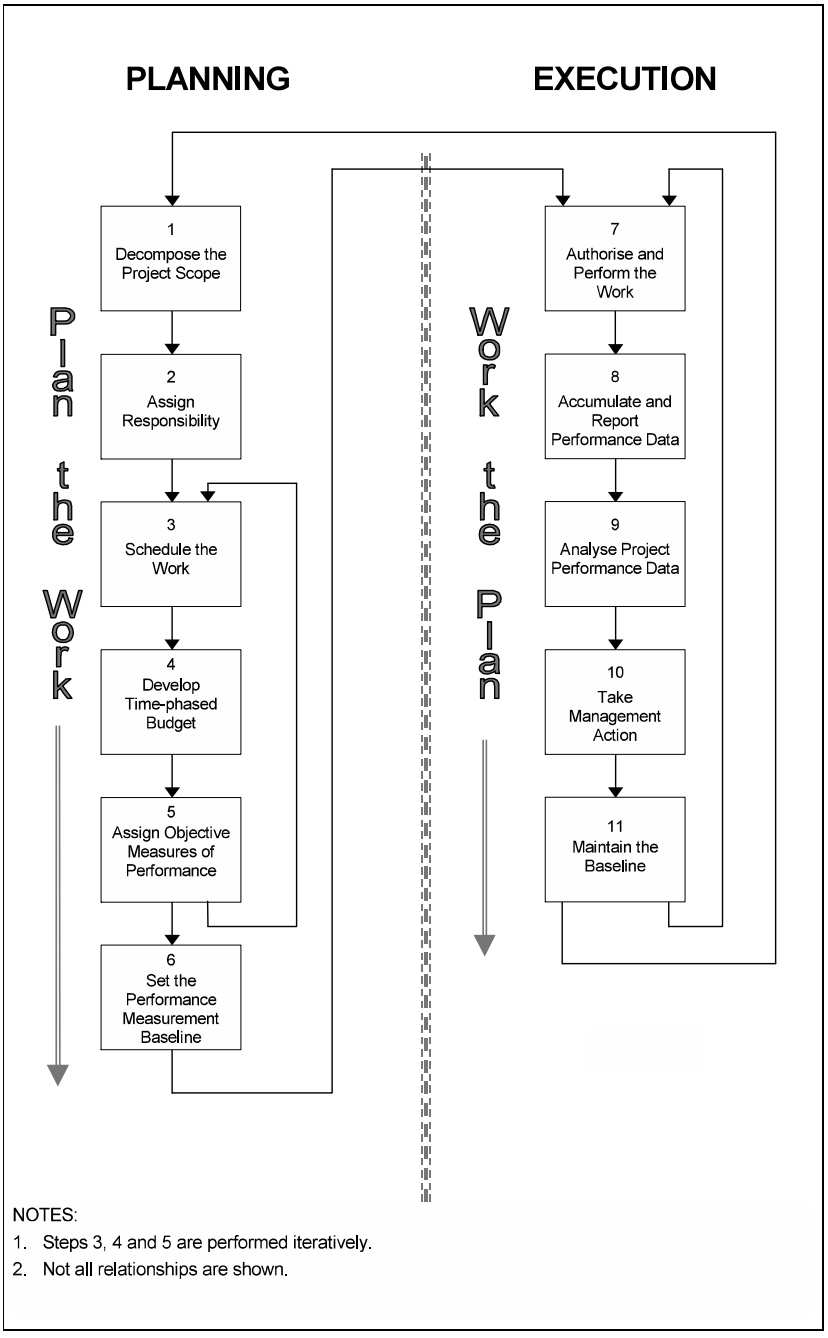


FIGURE 3.1 THE EVPM METHOD

3.1 STEP 1: Decompose the Project Scope

Decompose the entire PROJECT SCOPE of work into manageable elements.

3.1.1 *Requirements*

a. The PROJECT SCOPE SHALL be decomposed into a WBS.

b. The WBS SHALL include the entire SCOPE of work for the PROJECT.

c. The SCOPE of work elements SHALL be mutually exclusive.

3.1.2 *Guidance*

There are many other texts available on the topic of WBSs hence a comprehensive treatment will not be made in this Standard. Some of the key points of WBSs are as follows:

a. A well-structured WBS is a key to effective EVPM, as well as to integration of other elements of PROJECT MANAGEMENT (e.g. technical CONTROL, schedule management). Experience has demonstrated that effective WBSs identify products, DELIVERABLES, and/or outputs.

b. A parent WBS element SHOULD not include any work or ACTIVITIES that are not included in one of its sibling WBS elements. For example, if integration of two or more WBS elements is required, the integration EFFORT SHOULD be included in a separate WBS element or in one of the existing WBS elements. The integration Effort SHOULD not be included in the parent.

c. The same work SHOULD not be included in more than one WBS element.

d. A child element can belong to only one parent element.

e. A WBS DICTIONARY clearly and unambiguously defines what is included in each WBS element. A WBS DICTIONARY element MAY refer to a STATEMENT OF WORK, a product description, acceptance criteria, a specification or other documentation that defines the DELIVERABLE, product, or output of the particular WBS element.

f. A WBS SHOULD be developed down to the level needed to estimate and manage effectively.

3.2 STEP 2: Assign Responsibility

Assign responsibility for accomplishment of each element of the work at an appropriate management level.

3.2.1 *Requirements*

a. Performance responsibility SHALL be assigned for each element of the PROJECT and for the PROJECT in total.

b. Management responsibility SHALL be clearly defined.

c. Internal managers SHALL be responsible for any work to be performed externally.

3.2.2 *Guidance*

Once the SCOPE of work has been adequately decomposed into manageable elements, responsibility SHOULD be assigned for the performance of the work elements. The PM reviews the availability of internal and/or external resources to undertake each element of work in the decomposition. An ORGANISATION BREAKDOWN STRUCTURE (OBS) MAY be used to identify the organisational hierarchy responsible for work accomplishment.

A RESPONSIBILITY ASSIGNMENT MATRIX (RAM) MAY be used to map WBS elements to the OBS elements.

3.3 STEP 3: Schedule the Work

Create a schedule for all the work which identifies ACTIVITIES, durations, MILESTONES and interdependencies.

3.3.1 *Requirements*

a. ACTIVITIES SHALL be identified at or below the level of work elements.

b. Significant decision points, CONSTRAINTS, and interfaces SHALL be identified as key MILESTONES.

c. The authorised work SHALL be scheduled in a manner which describes the sequence of work and identifies ACTIVITY and MILESTONE interdependencies required to meet the requirements of the PROJECT.

d. Physical products, MILESTONES, technical performance goals or other objective measures of performance SHALL be clearly identified and used as indicators of performance and SHALL be the basis for EV determination.

3.3.2 *Guidance*

All elements of the work are scheduled into a logical sequence which identifies durations, ACTIVITIES, MILESTONES and interdependencies. In larger PROJECTS involving several layers of schedules, the schedule SHOULD be vertically and horizontally traceable i.e. all work SCOPE is traceable throughout the PROJECT to each level of schedule consistent with its level of planning, and that the logical relationship between ACTIVITIES is established.

The schedule is the vehicle used by line management to plan, perform and monitor the work of the PROJECT. The goal of such schedules is that they provide a vehicle for evaluating actual progress (in time) against pre-defined objective measurement of achievement.

All ACTIVITIES and MILESTONES within the one PROJECT SHOULD be linked with dependencies, to produce a NETWORK SCHEDULE such that the CRITICAL PATH can be determined, and the FREE FLOAT (FF) and TOTAL FLOAT (TF) can be determined for every ACTIVITY and MILESTONE.

A schedule SHOULD be established at the ACTIVITY level which provides the basis for assigning resources and developing the time phased BUDGET to be developed in the next step.

3.4 STEP 4: Develop Time-Phased Budget

Assign resources to ACTIVITIES, determining the cost of such resources and hence determine a time-phased BUDGET for the PROJECT.

3.4.1 *Requirements*

a. ACTIVITIES SHALL have a BUDGET value assigned which is expressed in terms of dollars, labour hours, or other measurable units.

b. BUDGETS assigned to ACTIVITIES SHALL be distributed over the ACTIVITY duration.

c. BUDGETS assigned to work SCOPE not yet planned in detail SHALL be distributed over the PROJECT to reflect the expected outcome of detail planning.

d. MANAGEMENT RESERVE BUDGETS MAY be created which are not assigned to ACTIVITIES or other work SCOPE. MANAGEMENT RESERVE SHALL be clearly identified as such.

e. The sum of the ACTIVITY BUDGETS plus BUDGETS for work SCOPE not yet planned in detail, UNDISTRIBUTED BUDGET (UB) and MANAGEMENT RESERVE SHALL equal the PROJECT BUDGET.

3.4.2 *Guidance*

BUDGETS (in terms of dollars, labour hours or other measurable units) SHOULD be assigned to all work elements and SHOULD separately identify labour, material, subcontract or any OTHER DIRECT COSTS (ODC). The time-phased BUDGET is defined as the PMB.

The total BUDGET at the completion of an ACTIVITY, WBS element or a PROJECT is termed the BAC for that ACTIVITY, WBS element or PROJECT.

The time phased representation of the total PV for all WBS elements will determine the PMB. The PMB represents the formal plan for each PM to do all the work assigned to them in the amount of time allocated and within the amount of BUDGET authorised to accomplish that work.

BUDGETS are time phased (whether planned in detail or not) so that BUDGET is tied to the work for which the BUDGET is provided. Hence it is important that work not yet planned in detail be time phased over the expected period of performance of the work. New BUDGET (UB) MAY exist for work SCOPE where no plans yet exist. UB is a component of the PMB (BAC).

Generally, an additional amount is set aside for MANAGEMENT RESERVE for any unanticipated tasks that are within the SCOPE of the PROJECT.

a. The TOTAL BUDGET for resources assigned to the PROJECT is equal to the BAC.

b. The BAC of the PMB plus MANAGEMENT RESERVE equals the PROJECT BUDGET.

3.5 STEP 5: Assign Objective Measures of Performance

Specify the objective measures to be used to measure work achievement.

3.5.1 *Requirements*

a. The accomplishment of ACTIVITIES SHALL be ultimately expressed in terms of the budgetary values of the ACTIVITIES (EV).

b. Objective measures of performance, SHALL be used to quantify the degree of completion of ACTIVITIES.

c. The EV of a completed ACTIVITY SHALL always equate to the amount budgeted for the ACTIVITY.

d. The objective measures of work performance SHALL be set prior to commencement of each ACTIVITY and SHALL not be changed once work has begun on the ACTIVITY.

e. Objective measures of performance SHALL be planned in the same manner in which they are to be assessed, and vice versa.

f. Objective measures of performance SHALL be established in such a manner that value is earned and actuals are accumulated in a consistent manner and in the same time frame when work proceeds according to plan.

g. Only one measure of performance SHALL be used per ACTIVITY.

3.5.2 *Guidance*

The objective measure of performance SHOULD be established in such a way that it correctly measures accomplishment of in-progress ACTIVITIES. This Standard does not specify any particular objective measure to be used. This will largely depend on ACTIVITY content, size, and duration. At all times, measuring EV SHOULD be computed using the same methodology as for the original plan (BUDGET). The resulting metric is referred to as the EV. Objective measures allow work achievement to be measured in a clear and unequivocal way. Setting the objective measures in advance enhances accountability and objectivity.

Performance measurement is generally done by assigning a specific EV technique to each WORK PACKAGE, or individual ACTIVITIES within a WORK PACKAGE. There is no definitive set techniques, but commonly used methods are described in various texts. The actual technique used will be dependent on the nature and duration of the work EFFORT. A simple example is the technique termed '0/100'; EV is only claimed when the element is completed (100%). Another technique '50/50' is used when 50% of EV is claimed on commencement and 50% on completion. Each of the techniques has limitations and it is normally the responsibility of management to ensure that an appropriate, reliable and objective technique is applied to each ACTIVITY. Where possible the objective measures of performance established in Step 3 SHOULD be used as a basis for the EV technique.

Performance can be measured in terms of dollars, labour hours or other measurable units. The performance measurement indicators (MILESTONES, etc) SHOULD be scheduled with sufficient frequency to provide a basis for accurate performance measurement. Additionally, performance measurement SHOULD be consistent with the time intervals in the PMs accounting and budgeting periods.

3.6 STEP 6: Set the Performance Measurement Baseline

Formally establish the planning parameters determined in earlier steps as the PMB for the PROJECT.

3.6.1 *Requirements*

a. The work SCOPE of individual elements and the PROJECT in total SHALL be clearly identified and recorded.

b. The work SCOPE of the individual elements SHALL be consistent with each other and the PROJECT objectives in total.

c. The schedule of the individual ACTIVITIES and PROJECT in total SHALL be clearly developed and recorded.

d. The schedule of the individual ACTIVITIES SHALL be appropriately integrated with each other and consistent with the overall PROJECT objectives.

e. The BUDGETARY values of the individual elements and the PROJECT in total SHALL be clearly developed and recorded and the association between an element and its BUDGET SHALL not be varied except as a formal BASELINE maintenance procedure (Step 11)

f. The WBS, WORK SCOPE, schedule, and BUDGET for each ACTIVITY and the time-phased BUDGET, when appropriately integrated with each other, SHALL be approved by the PM or higher authority.

g. The WBS, WORK SCOPE, schedule, and BUDGET for each ACTIVITY and the time-phased BUDGETS, as approved, SHALL be recorded as the PMB and subject to formal change CONTROL as explained in Step 11: Maintain the BASELINE.

3.6.2 *Guidance*

The BASELINE provides the reference points against which actual PROJECT progress is compared, it SHOULD include the best estimates for task duration, scheduling, resource allocation, costs, and the other PROJECT variables required to be monitored.

To be valid, a BASELINE SHOULD not only be logically constructed but it SHOULD make sense when compared to available PROJECT resources. A quick way to judge this is to plot the BUDGETS against time on an accumulating basis as an S-Curve. The shape of the curve SHOULD be used to assess the achieveability of the plan. A sudden change in the slope of the curve indicates a sudden change in the applied resources and invites attention to the ability to ramp up or down quickly.

Prerequisites to establishing the PMB are as follows:

a. All PROJECT product DELIVERABLES have been accounted for within the SCOPE decomposition.

b. All integration roles and responsibilities for each major DELIVERABLE have been assigned and are clearly visible.

c. The BUDGETS for tasks are as realistic as possible.

d. There is a management commitment to the BASELINE costs, schedule and SCOPE targets.

e. All tasks have been assigned resources that actually carry out the work or are needed to complete the work.

3.7 STEP 7: Authorise and Perform the Work

Formally authorise all work to be undertaken and perform the work.

3.7.1 *Requirements*

a. The source of authority for commencement of work SHALL be clearly identified.

b. All work SHALL be planned before it is authorised.

c. All work SHALL be authorised to commence in the manner in which it was planned.

d. Authorisation SHALL clearly identify responsibility for performing the ACTIVITY and the methods for accumulating the cost of performance.

3.7.2 *Guidance*

In order for the PM to exercise proper CONTROL of the PROJECT, it is necessary that the chain of authorisation for the commencement of work emanate from the PM either directly or indirectly. If a formal authorisation system is required involving several layers of authorisation documentation, there SHOULD be a clear trace from the ultimate authorisation document to the detailed authorisation document. The work authorisation for each level SHOULD clearly identify:

- What is to be done.
- Who is to do it.
- When it is to be done.
- Amount of resources BUDGETED.
- Acceptance by person responsible for work.
- How progress and ACS are to be aggregated.

3.8 STEP 8: Accumulate and Report Performance Data

Record and accumulate schedule progress, EV and AC for each ACTIVITY. Report performance as appropriate.

3.8.1 *Requirements*

a. The current schedule SHALL be progressed to show achievement and to provide forecast of completion dates of scheduled work.

b. The EV for an ACTIVITY SHALL be accumulated for subsequent comparison with the PV for the ACTIVITY.

c. The ACS recorded SHALL include all and only the cost incurred for the work accomplished.

d. ACs incurred in the performance of the ACTIVITY SHALL be accumulated for subsequent comparison with the EV for the ACTIVITY.

e. Schedule forecasts at completion SHALL be readily available for comparison with status information.

f. The PV, EV, ACS, BAC and ESTIMATE TO COMPLETE (ETC) SHALL be logically summarised through the PROJECT decomposition to properly represent the status of the individual ACTIVITIES and the PROJECT in total.

g. All performance data SHALL be accumulated on a consistent and periodic basis with a common date.

h. Performance reports SHALL be distributed to appropriate management levels on a consistent and periodic basis.

3.8.2 *Guidance*

The accumulation of performance data refers to BUDGETED costs, EV, ACS and ESTIMATES TO COMPLETE. In addition it requires the accumulation of scheduling data, identifying current status of scheduled ACTIVITIES, forecast completion dates of current and future ACTIVITIES.

The point of accumulation of AC SHOULD be at a level which will identify the cost elements and factors contributing to CVS. AC SHOULD be recorded in a manner consistent with the BUDGET and SHOULD include all resource expenditures.

The performance data SHOULD be aggregated up through the WBS in a manner which allows for easy traceability of higher level element variances to the source elements at a more detailed level.

3.9 STEP 9: Analyse Project Performance Data

Identify and analyse CV and SVs and develop estimates of cost at completion and forecasts of schedule completion.

3.9.1 *Requirements*

a. EV for ACTIVITIES and work elements SHALL be compared with the corresponding PV to determine the SV.

b. The progressed (current) schedule SHALL be compared with the BASELINE schedule to determine slippages and forecast dates and changes to the CRITICAL PATH and remaining FLOAT for NETWORK SCHEDULES.

c. EV for ACTIVITIES and work elements SHALL be compared with the corresponding AC to determine the CV.

d. CV and SV SHALL be analysed to determine the cause and impact on the PROJECT and the required CORRECTIVE ACTION.

e. ESTIMATES AT COMPLETION (EAC) SHALL be routinely developed and updated based on past trends and current knowledge and compared with the corresponding BAC to identify the extent of the VARIANCE AT COMPLETION.

f. Forecasts of schedules at completion SHALL be routinely developed and updated based on past trends and current knowledge for comparison with the planned completion dates.

3.9.2 *Guidance*

Performance measurement SHOULD be undertaken on a consistent and periodic basis. The reporting period SHOULD be appropriate for the overall duration of the PROJECT and management reporting requirements. Measurement and analysis SHOULD be undertaken at the level at which responsibility has been assigned. In more complex PROJECTS this MAY entail several layers of management or several levels of the WBS.

Management by exception principles MAY be facilitated by establishing variance thresholds to discount non-significant variances and identify only those variances that require further analysis.

MANAGEMENT RESERVE usage SHOULD be analysed to enable forecasts of future usage.

3.10 STEP 10: Take Management Action

Take management action to compensate for past deviations or rectify projected deviations from PROJECT PLANS.

3.10.1 *Requirements*

a. CORRECTIVE ACTION plans SHALL be developed and implemented based on analysis of the identified cost, schedule and projected deviations from PROJECT PLANS.

b. Forecasts SHALL be revised based on approved CORRECTIVE ACTIONS and BASELINES SHALL be changed as necessary in accordance with BASELINE maintenance procedures

c. Retroactive changes to cost, schedule or technical plans SHALL not be enacted.

d. Projection and status of CORRECTIVE ACTION plans SHALL be followed up during subsequent periods of the PROJECT.

3.10.2 *Guidance*

The required CORRECTIVE ACTION is determined by the source and cause of the variance. Variances MAY have several dimensions. Variances MAY arise from poor planning, unforeseen SCOPE CHANGES, technical problems, equipment failures or other exogenous factors such as supplier difficulties. Regardless of the cause, CORRECTIVE ACTIONS require either a change in the BASELINE planning or the development of a short term get well plan that is incorporated in the forecasts. In either case, revisions to planning SHOULD only be accomplished prospectively. Retroactive changes to cost, schedule or technical planning or accomplishment SHOULD not be allowed other than to correct administrative or typographical errors.

3.11 STEP 11: Maintain the Baseline

Manage and track the introduction of approved changes to the PMB.

3.11.1 *Requirements*

a. Changes to the BASELINE planning SHALL be accomplished only with attendant approved changes to the SCOPE, schedule or BUDGET of the PROJECT.

b. All changes to the BASELINE SHALL be documented and traceable.

c. Retroactive changes to BASELINE SCHEDULE, cost or SCOPE SHALL not be made.

3.11.2 *Guidance*

Changes to the BASELINE planning can originate either internally through the identification of unforeseen SCOPE CHANGES or resource requirements, or where changes have been directed from other stakeholders. Where there have been changes to the PROJECT, it will be necessary to re-plan certain elements of the work.

Except in small PROJECTS, routine and regular changes to the BASELINES SHOULD be anticipated as work is planned in progressively more detail to a point where it is packaged ready for execution. Such changes are INTERNAL REPLANS and MAY reflect the refinement of work through stages of UB, higher level planning accounts, CONTROL ACCOUNTS, PLANNING PACKAGES, WORK PACKAGE and ACTIVITIES. Such planning follows the processes described in Steps 3 to 5 which are applied iteratively until developed and incorporated as a formal change to the BASELINE.

Due to the importance of maintaining a valid BASELINE for performance measurement, re-planning SHOULD be accomplished:

- with proper authority;
- in a systematic and timely manner;
- with careful control; and
- with adequate and visible documentation.

Re-planning SHOULD not be used as an alternative to proper initial planning, nor SHOULD it be used to mask legitimate variances.

Maintenance of the PMB is required to ensure that BASELINE changes are properly recorded and visible and can be examined to determine their causes and potential impact on completion dates and costs.

In order to maintain the integrity of the PMB the PM SHOULD not transfer SCOPE or BUDGET independently of one another. Additionally, retroactive changes to cost, schedule or technical planning or accomplishment SHOULD not be allowed except to correct typograhical errors, accounting errors or errors in the recording of accomplishment.

ANNEX A

GLOSSARY

(Normative)

For the purposes of this Standard, the definitions below apply.

TERM	DEFINITION
ACTIVITY	An element of work performed during the course of a PROJECT. An ACTIVITY normally has an expected duration, an expected cost, and expected resource requirements. ACTIVITIES can be subdivided into tasks.
ACTUAL COST (AC)	The costs actually incurred and recorded in accomplishing work performed.
ACTUAL COST OF WORK PERFORMED (ACWP)	This term has been replaced with the term 'ACTUAL COST'.
APPORTIONED EFFORT	EFFORT that by itself is not readily measured or divisible into discrete WORK PACKAGES but which is related in direct proportion to the planning and performance of other measured EFFORT.
BASELINE	The original approved plan (for a PROJECT, a WORK PACKAGE, or an ACTIVITY), plus or minus approved SCOPE CHANGES. Usually used with a modifier (e.g., cost baseline, SCHEDULE BASELINE, PERFORMANCE MEASUREMENT BASELINE).
BUDGET	A cost target, based on the planned resource requirements (labour, material, OTHER DIRECT COSTS and possibly overhead), for a given SCOPE of work. The BUDGET is used for performance measurement and management purposes and generally remains static unless there is a variation in the SCOPE of work or other approved changes. Where the term BUDGET AT COMPLETION is used, it is synonymous with BUDGET.
BUDGET AT COMPLETION (BAC)	The total authorised BUDGET for accomplishing the PROJECT SCOPE of work. It is equal to the sum of all allocated BUDGETS plus any UNDISTRIBUTED BUDGET. (MANAGEMENT RESERVE is not included.) The BUDGET AT COMPLETION will form the PERFORMANCE MEASUREMENT BASELINE as it is allocated and time-phased in accordance with Project schedule requirements.
BUDGETED COST OF WORK PERFORMED (BCWP)	This term has been replaced with the term 'EARNED VALUE'.
BUDGETED COST OF WORK SCHEDULED (BCWS)	This term has been replaced with the term 'PLANNED VALUE'.

TERM	DEFINITION
CONSTRAINT	Applicable restriction that will affect the performance of the PROJECT. Any factor that affects when an ACTIVITY can be scheduled.
CONTROL	The process of comparing actual performance with planned performance, analysing variances, evaluating possible alternatives, and taking appropriate CORRECTIVE ACTION as needed.
CONTROL ACCOUNT	A management CONTROL point at which BUDGETS (resource plans) and ACTUAL COST are accumulated and compared to EARNED VALUE for management CONTROL purposes. A CONTROL ACCOUNT is a natural management point for planning and CONTROL since it represents the work assigned to one responsible organisational element on one PROJECT WORK BREAKDOWN STRUCTURE element.
CORRECTIVE ACTION	Changes made to bring expected future performance of the PROJECT in line with the plan (i.e. the BASELINE).
COST ACCOUNT	This term has been replaced with the term 'CONTROL ACCOUNT'.
COST PERFORMANCE INDEX (CPI)	The cost efficiency ratio of EARNED VALUE to ACTUAL COST. COST PERFORMANCE INDEX is often used to predict the magnitude of a possible cost overrun using the following formula: *BAC / CPI* = projected cost at completion A positive value indicates a favourable position and a negative value indicates an unfavourable condition. *CPI = EV / AC*
COST VARIANCE (CV)	The algebraic difference between the EARNED VALUE and the ACTUAL COST. *CV = EV – AC*. A positive value indicates a favourable position and a negative value indicates an unfavourable condition.
CRITICAL PATH	The series of ACTIVITIES that determine the duration of the PROJECT. In a deterministic model the CRITICAL PATH is usually defined as those ACTIVITIES with FLOAT less than or equal to a specified value, often zero. It is the longest path through the PROJECT.
DELIVERABLE	Any measurable, tangible, verifiable outcome, result or item that must be produced to complete a PROJECT or part of a PROJECT. Often used more narrowly in reference to an external DELIVERABLE, which is a DELIVERABLE that is subject to approval by the PROJECT sponsor or customer.
DIRECT COSTS	The costs or resources expended in the accomplishment of work which are directly charged to the relevant work.
EARNED VALUE (EV)	The value of completed work expressed in terms of the BUDGET assigned to that work. Previously, also called the BUDGETED COST OF WORK PERFORMED (BCWP).

TERM	DEFINITION
EARNED VALUE PERFORMANCE MEASUREMENT (EVPM)	A method for integrating SCOPE, schedule and resources and for measuring PROJECT performance. It compares the amount of work that was planned with what was actually earned and what was actually spent to determine if cost and schedule performance are as planned.
EFFORT	The number of labour units required to complete an ACTIVITY or other PROJECT element. Usually expressed as person-hours, person-days, person-weeks or person-months. Should not be confused with duration.
ESTIMATE AT COMPLETION (EAC)	The expected total cost of an ACTIVITY, a group of ACTIVITIES, or the PROJECT when the defined SCOPE of work has been completed. It equals ACTUAL COSTS to a point in time plus the estimated costs to completion (ESTIMATE TO COMPLETE).
ESTIMATE TO COMPLETE (ETC)	The expected additional cost needed to complete an ACTIVITY, a group of ACTIVITIES, or the PROJECT. Most techniques for forecasting ESTIMATE TO COMPLETE include some adjustment to the original estimate, based on PROJECT performance to date. (See also ESTIMATE AT COMPLETION)
FINISH DATE	A point in time associated with an ACTIVITY'S completion. Usually qualified by one of the following: actual, planned, estimated, scheduled, early, late BASELINE, target, or current.
FLOAT	The amount of time that an ACTIVITY MAY be delayed from its early start without delaying the PROJECT FINISH DATE. FLOAT is a mathematical calculation, and can change as the PROJECT progresses and the schedule is updated. Also called slack, TOTAL FLOAT, and path FLOAT. (See also FREE FLOAT)
FREE FLOAT (FF)	The amount of time that an ACTIVITY can be delayed without delaying the early start of any immediately following ACTIVITIES. (See also FLOAT)
FUNDS	The amount of money actually required to fund the completion of the total EFFORT for a given work SCOPE. This is distinct from BUDGET in that the funding requirements are updated regularly to reflect the latest known (ACTUAL COST) and forecast costs (ESTIMATE TO COMPLETE). The forecast funding requirements are represented by the Estimate Completion or ESTIMATE AT COMPLETION, although these MAY not necessarily represent company approval to expend FUNDS.
INDEPENDENT ESTIMATE AT COMPLETION (IEAC)	The INDEPENDENT ESTIMATE AT COMPLETION is an estimate by independent persons or process other than management. It is normally equal to ACTUAL COST plus an independently generated ESTIMATE AT COMPLETION.
INDIRECT COSTS	The cost for common or joint objectives which cannot be identified specifically with a particular PROJECT or ACTIVITY. Also referred to as 'overhead cost' or 'burden'.

TERM	DEFINITION
INTERNAL REPLANNING	Replanning actions for remaining work SCOPE. A normal PROJECT CONTROL process accomplished within the SCOPE, schedule, and cost objectives of the PROJECT.
LEVEL OF EFFORT (LOE)	Unmeasured EFFORT of a general or supportive nature usually without a DELIVERABLE end product. Examples are supervision, PROJECT administration and contract administration.
MANAGEMENT RESERVE	An amount of the total BUDGET withheld for management CONTROL purposes rather than designated for the accomplishment of a specific ACTIVITY or set of ACTIVITIES.
MAY	Indicates the existence of an option.
MILESTONE	A significant event in the PROJECT, usually completion of a major deliverable.
NETWORK SCHEDULE	A schedule format in which the ACTIVITIES and MILESTONES are represented along with the interdependencies between ACTIVITIES. It expresses the logic of how the PROJECT will be accomplished. NETWORK SCHEDULES are the basis for CRITICAL PATH analysis, a method for identification and assessment of schedule priorities and impacts.
ORGANISATION BREAKDOWN STRUCTURE (OBS)	The hierarchical arrangement for the management organisation for a project, graphically depicting the reporting relationships. The organisation structure MAY include work teams, functions or whatever organisation units are used by an organisational entity.
OTHER DIRECT COSTS (ODC)	Usually the remaining DIRECT COSTS, other than labour and material, such as travel and computer costs.
PERCENT COMPLETE	An estimate, expressed as a percent, of the amount of work that has been completed on an ACTIVITY or a group of ACTIVITIES.
PERFORMANCE MEASUREMENT BASELINE (PMB)	The total time-phased BUDGET plan against which PROGRAM performance is measured. It is the schedule for expenditure of the resources allocated to accomplish PROGRAM SCOPE and schedule objectives and is formed by the BUDGETS assigned. The PERFORMANCE MEASUREMENT BASELINE also includes BUDGET for future EFFORT assigned to higher WORK BREAKDOWN STRUCTURE levels (summary level PLANNING PACKAGES, plus any UNDISTRIBUTED BUDGET. MANAGEMENT RESERVE is not included in the BASELINE as it is not yet designated for specific work SCOPE.
PLANNED VALUE (PV)	The sum of the BUDGETS for work scheduled to be accomplished plus the amount of LEVEL OF EFFORT and APPORTIONED EFFORT scheduled to be accomplished within a given time period. Previously this was called the BUDGET COST OF WORK SCHEDULED (BCWS).

TERM	DEFINITION
PLANNING PACKAGE	A logical aggregation of work, usually future efforts that can be identified and budgeted, but which is not yet planned in detail at the WORK PACKAGE or ACTIVITY level.
PROGRAM	A group of related PROJECTS managed in a co-ordinated way. PROGRAMS usually include an element of ongoing work.
PROJECT	A temporary endeavour undertaken to create a unique product, service, or result.
PROJECT BUDGET	The total BUDGET for the PROJECT including all allocated BUDGET, MANAGEMENT RESERVE, and UNDISTRIBUTED BUDGET.
PROJECT MANAGEMENT	The application of knowledge, skills, tools, and techniques to PROJECT ACTIVITIES to meet the PROJECT requirements.
PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK)	An inclusive term that describes the sum of knowledge within the profession of PROJECT MANAGEMENT. As with other professions (such as law, medicine, and accounting) the body of knowledge rests with the practitioners and academics that apply and advance it. The PROJECT MANAGEMENT BODY OF KNOWLEDGE includes proven, traditional practices that are widely applied, as well as innovative and advanced ones that have seen more limited use.
PROJECT MANAGER (PM)	The individual responsible for managing a PROJECT.
PROJECT PLAN	A formal, approved document used to guide both PROJECT execution and PROJECT CONTROL. The primary uses of the PROJECT PLAN are to document planning assumptions and decisions, facilitate communication among stakeholders, and document approved SCOPE, cost, and SCHEDULE BASELINES. A PROJECT PLAN MAY be summary or detailed.
PROJECT SCOPE	The work that must be done to deliver a product with the specified features and functions.
RESERVE	A provision in the PROJECT PLAN to mitigate cost and/or schedule risk. Often used with a modifier (e.g., schedule RESERVE, MANAGEMENT RESERVE, contingency RESERVE) to provide further detail on what types of risk are meant to be mitigated. The specific meaning of the modified term varies by application area.
RESPONSIBILITY ASSIGNMENT MATRIX (RAM)	A structure that relates the PROJECT Organisation Breakdown Structure to the WORK BREAKDOWN STRUCTURE to help ensure that each element of the PROJECT'S SCOPE of work is assigned to a responsible individual.
SCHEDULE PERFORMANCE INDEX (SPI)	The schedule efficiency ratio of EARNED VALUE accomplished against the PLANNED VALUE. The SCHEDULE PERFORMANCE INDEX describes what portion of the planned schedule was actually accomplished. $SPI = EV / PV$

TERM	DEFINITION
SCHEDULE VARIANCE (SV)	A metric for the schedule performance on a program. It is the algebraic difference between EARNED VALUE and the BUDGET. $SV = EV - BUDGET$ A positive value is a favourable condition while a negative value is unfavourable.
SCOPE	The sum of the products and services to be provided as a PROJECT. See PROJECT SCOPE.
SCOPE CHANGE	Any change to the project scope. A SCOPE CHANGE almost always requires an adjustment to the project cost schedule.
SHALL	Indicates that a statement is mandatory.
SHOULD	Indicates a recommendation.
STATEMENT OF WORK	The document that defines the work SCOPE requirements for a PROJECT.
TOTAL FLOAT (TF)	See FLOAT.
UNDEFINITIZED WORK	Authorised work for which a value has not been negotiated or otherwise determined. Previously called Authorised Unpriced Work (AUW)
UNDISTRIBUTED BUDGET (UB)	BUDGET associated with specific work SCOPE or PROJECT changes which has not been assigned to a CONTROL ACCOUNT or Summary Level Planning Package.
VARIANCE AT COMPLETION	Algebraic difference between BUDGET AT COMPLETION and ESTIMATE AT COMPLETION. $VAC = BAC - EAC$
WORK BREAKDOWN STRUCTURE (WBS)	A product oriented division of PROJECT work depicting the breakdown of work SCOPE for work authorisation, tracking and reporting purposes.
WORK BREAKDOWN STRUCTURE DICTIONARY	A list of WORK BREAKDOWN STRUCTURES elements with a description of the work SCOPE content in each element. The work descriptions are normally summary level and provide for clear segregation of work for work authorisation and accounting purposes.
WORK PACKAGE	An ACTIVITY or set of ACTIVITIES performed within a CONTROL ACCOUNT.

ANNEX B

MEASURING AND ANALYSING PERFORMANCE

(Informative)

B1 Introduction

B1.1 *General*

Provided that accurate and relevant EVPM data has been collected, meaningful performance information MAY be obtained. The data and information can be analysed to derive performance forecasts, thus rendering useful management information. This Annex deals with the basic concepts of EVPM and analysis.

Care must always be taken to ensure that the data is relevant, i.e. it is accurate and related to the correct element of work and associated with the correct period of time. In this Annex, data is often intended to be cumulative, i.e. it relates to the period from inception to the last accounting period. Many data elements formulae have general application and MAY be applied to whole PROJECTS, elements within PROJECTS and cumulative or current accounting periods.

Measurement of EV data will reveal:

- Basic cost performance.
- Basic schedule performance (in terms of value of work performed compared with the plan).

From these can be derived formulae or expressions showing:

- COST PERFORMANCE INDICES (CPI) and SCHEDULE PERFORMANCE INDICES (SPI).
- Basic progress indices.
- Forecasts based on past performance.
- Performance required to achieve at completion conditions.

Analysis of EVPM information entails measurement, derivation of information, comparison of EVPM and indicators with other performance measures such as performance against schedule. Finally, the EV data can be used to condition or test management forecasts.

B1.2 *Basic Cost Performance*

Cost performance compares EV with the AC of performing that work. Any difference between EV and AC is referred to as a CV. This MAY be either a positive or a negative variance. The metric for determining CV is:

$$CV = EV - AC$$

Example A: Work in Process

A foundation slab is planned to cost (and assigned a value of) $10 000. The job was planned to be undertaken over, say, four accounting periods.

At the end of the second accounting period, the EV is $4000 ($4000 worth of work has been done). But the AC is $3800 (the work to date has been achieved at a cost of only $3800). The cumulative CV to date is:

$$CV_{(\text{slab})} = EV - AC = \$4000 - \$3800 = \$200$$

Example B: At Completion

A foundation slab is planned to cost (and assigned a value of) $10 000. The job is now complete and the contractor is paid $9500. Thus the CV is:

$$CV_{(\text{slab})} = EV - AC = \$10\,000 - \$9500 = \$500$$

In order to calculate the cost performance for a particular period, it is required to know how much value was earned, but it is not required to know how much work was originally planned for that period.

B1.3 *Basic Schedule Performance*

To measure schedule performance during a specific period, the value of the work planned to be achieved during that period must be known, i.e. the PV. Schedule performance is determined by comparing EV with PV. Any difference is referred to as a SV. Thus the metric for determining SV is:

$$SV = EV - PV$$

Example: $10 000 worth of work was scheduled for the month of January (PV = $10 000). However only $8000 worth of work was achieved (EV = $8000). Thus:

$$SV_{(\text{January})} = EV - PV = \$8000 - \$10\,000 = -\$2000$$

NOTES:

1 In order to calculate the schedule performance during a particular period, it is not necessary to know the cost of the work achieved only the budgeted cost for that work.

2 EV data does not give a direct expression of days ahead or behind schedule. The SV is expressed in terms of value of the work and other devices will be necessary to relate this to a calendar. Reliable analysis will normally require an understanding of the nature of the work and the EVPM methodology. For example, SV due to non-receipt of material might be recovered very quickly (material is delivered); while a similar SV due to loss of production due to weather is unlikely to be recovered without management intervention.

3 EV is essential to derive cost and schedule performance: the other two elements (PV and AC) render no useful performance information without EV.

B2 Formulae

B2.1 *Scope*

In order to facilitate analysis, a range of simple formulae exist and some of the most commonly used EVPM formulae are detailed in this Section.

B2.2 *Percent Complete or Spent*

Percent Complete of Plan	$\frac{EV \times 100}{BAC}$
Percent Spent of Plan	$\frac{AC \times 100}{BAC}$
Percent Spent of Estimate at Completion	$\frac{AC \times 100}{EAC}$

B2.3 *Performance Indices and Percentages*

Percent Cost Variance	*CV*%	$\frac{CV \times 100}{EV} = \frac{(EV - AC) \times 100}{EV}$
Cost Performance Index	*CPI*	$\frac{EV}{AC}$
Percent Schedule Variance	*SV*%	$\frac{SV \times 100}{PV} = \frac{(EV - PV) \times 100}{PV}$
Schedule Performance Index	*SPI*	$\frac{EV}{PV}$

B2.4 *At Completion Formulae*

At completion formulae differ from the previous cost and schedule information in that they all rely upon managerial estimates.

Estimate at Completion	*EAC*	$AC + ETC$
Variance at Completion	*VAC*	$BAC - EAC$
Variance at Completion Percent	*VAC*%	$\frac{VAC \times 100}{BAC} = \frac{(BAC - EAC) \times 100}{BAC}$

B2.5 *Independent Estimates at Completion (IEACs)*

IEACs might be generated by intelligent consideration of the attributes of past performance that might affect future performance. Each IEAC is an adaptation of the general formula where:

$$IEAC = AC + (BAC - EV) \times FF$$

Where FF is an algebraic 'forecast factor'. Note that FF is FREE FLOAT elsewhere in this Standard.

An example of IEAC is as follows:

IEAC assumes future cost performance will be same as past performance	$IEAC = AC + \frac{(BAC - EV)}{CPI} = \frac{BAC}{CPI}$
IEAC assumes future cost performance will be influenced by 80% past cost and 20% past schedule performance	$IEAC = AC + \frac{(BAC - EV)}{0.8 \times CPI + 0.2 \times SPI}$
IEAC assumes future cost performance will be influenced by the last 3 months cost performance	$IEAC = AC + \frac{(BAC - EV)}{CPI_1 + CPI_2 + CPI_3}$
IEAC assumes future cost performance will be influenced by past cost and schedule performance	$IEAC = AC + \frac{(BAC - EV)}{CPI \times SPI}$

B2.6 *To Complete Indices*

The To Complete Performance Index (TCPI) indicates how well the element must perform (in comparison with the plan) from now to completion in order to achieve a specified final cost. (Normally the PM is interested in knowing whether the BAC or the EAC will be achieved).

If the TCPI > 1, then performance needs to be better than planned.

To Complete Performance Index (BAC)	$TCPI_{BAC}$	$\frac{(BAC - EV)}{(BAC - AC)}$
To Complete Performance Index (EAC)	$TCPI_{EAC}$	$\frac{(BAC - EV)}{(EAC - AC)}$

B3 Analysis

B3.1 *General*

Analysis is generally achieved by intelligent examination of data. It MAY be assisted by application of specialised analysis tools and sorting of data into specific categories. While EVPM data alone can reveal useful information, analysis SHOULD normally be conducted against a background understanding of the technical nature of the PROJECT and historical performance. Finally, consideration of EVPM data SHOULD not be undertaken in isolation: cost and schedule forecasts SHOULD, for example, include careful examination of risk, schedule and management forecasts.

Measurement and analysis SHOULD be routine ACTIVITIES leading to, and consistent with, updated forecasts.

Processes SHOULD include:

- Quick-look analysis (note basic variances, check PERCENT COMPLETE against percent spent, examine TCPIs etc.)
- Compare EVPM data with other forecasts
- Generate EACs and forecasts
- Routine analysis of causes and variances

B3.2 *Use of Indices*

If an index is:

a. = 1, then that element is performing exactly to plan;

b. < 1, then that element is performing less than plan; and

c. > 1, then that element is performing greater than plan.

If a CPI is 0.85 then this SHOULD be interpreted as meaning for every $1 spent, 85c of value is achieved (in comparison with the plan), i.e. overspending by comparison with the plan.

If a SPI is 0.85, then 85% by value of the work planned to be achieved in the period has been completed, i.e. underachieving by comparison with the plan.

B3.3 *Variance Analysis*

Variance analysis SHOULD include the following:

a. Quantification of the variance and its components.

b. Identification of the cause(s) of the components of the variance.

c. Identification and quantification of the immediate impact(s) of the variance.

d. Identification of measures to mitigate the impact(s).

The processes or systems used in the analysis will depend on the particular PROJECT, the organisation involved and its particular system and processes. However, analysis normally involves examining the integrated cost, schedule and technical aspects.

B3.4 *Reliability of the Estimate at Completion*

The IEAC formulae each produce an objective estimate based on observed and measured performance. They MAY be used to provide an independent indication of the reliability of the EAC. If there is a reasonable consistency between the EAC and the four (4) IEAC, then the EAC can be viewed as reasonable based on past performance. If there is a difference then the question must be asked 'why?'.

ANNEX C

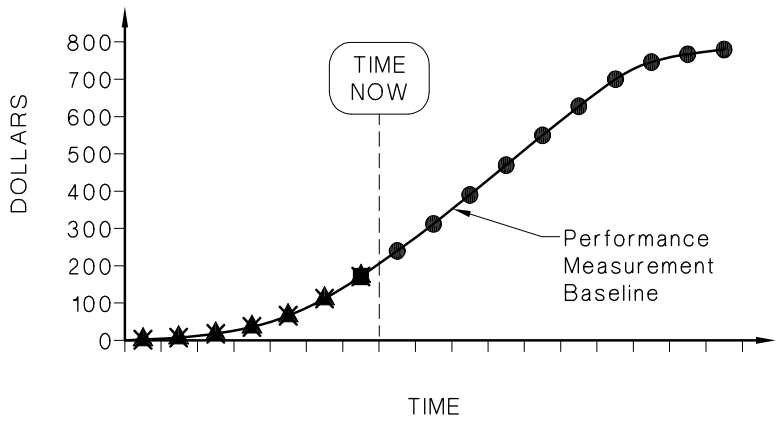
COMMON CHARTS AND THEIR INTERPRETATION

(Informative)

This Annex contains examples of how EVPM data can be presented in some common charts and illustrates how they assist in interpretation of the data. The charts shown here can be applied to the whole PROJECT or to any element of the PROJECT.

C1 Cumulative Performance Chart

The chart in Figure C1 presents the cumulative performance for a fictional Project X. By depicting the basic data elements it conveys an overall picture of PROJECT performance.

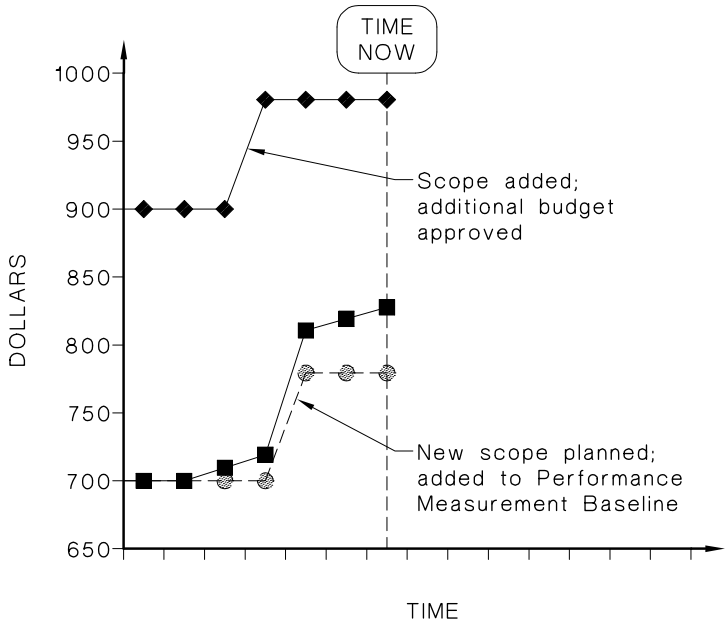


	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Planned Value (PV)	0	10	20	40	70	120	170	240	310	390	470	550	630	700	750	770	780
Earned Value (EV)	0	10	19	37	66	113	161										
Actual Cost (AC)	0	9	18	36	67	115	165										

FIGURE C1 PROJECT X – PAST PERFORMANCE, CURRENT STATUS AND FORECAST

C2 'At Completion' History Chart

The chart in Figure C2 depicts the changes in the value of three important parameters for the total PROJECT (Project X) and the point in time where the values change. To a degree, the source of the change can be identified. A change in the BAC can be caused either by INTERNAL REPLANNING or an external change. Thus, a change in the BAC accompanied by a corresponding change in the PROJECT BUDGET would be caused by an external change. Conversely, a change in the BAC without a change in the PROJECT BUDGET would be caused by INTERNAL REPLANNING. Finally, the VARIANCE AT COMPLETION can be interpreted from the chart; it is the difference between the BAC and the EAC.

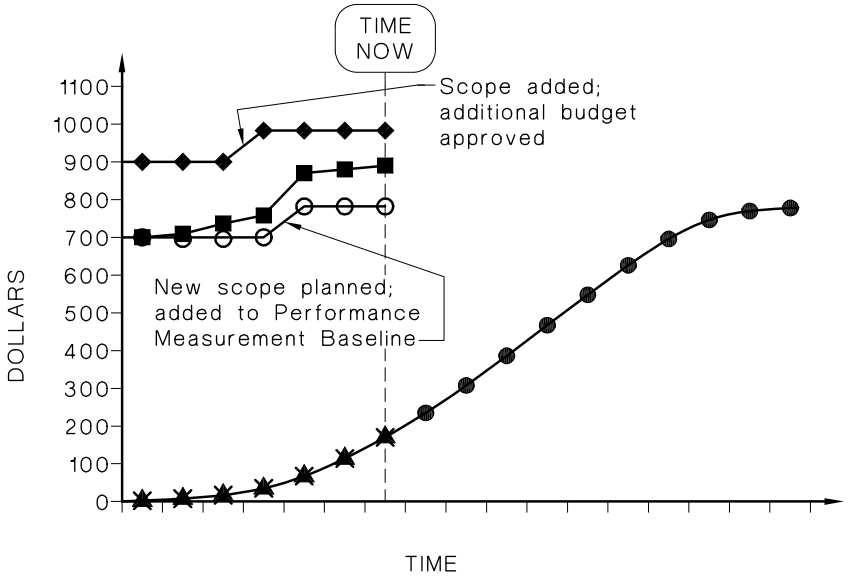


	Apr	May	Jun	Jul	Aug	Sep	Oct
Project Budget (PB)	900	900	900	980	980	980	980
PMB Budget at Completion	700	700	700	780	780	780	780
Estimate at Completion (EAC)	700	700	710	800	810	820	828

FIGURE C2 PROJECT X – 'AT COMPLETION' HISTORY

C3 Combined Performance Chart

The chart in Figure C3 presents the cumulative performance (the S-Curves). It also displays changes to the PROJECT BUDGET, BAC and EAC. By displaying the basic data elements in one chart it conveys an overall picture of PROJECT performance.

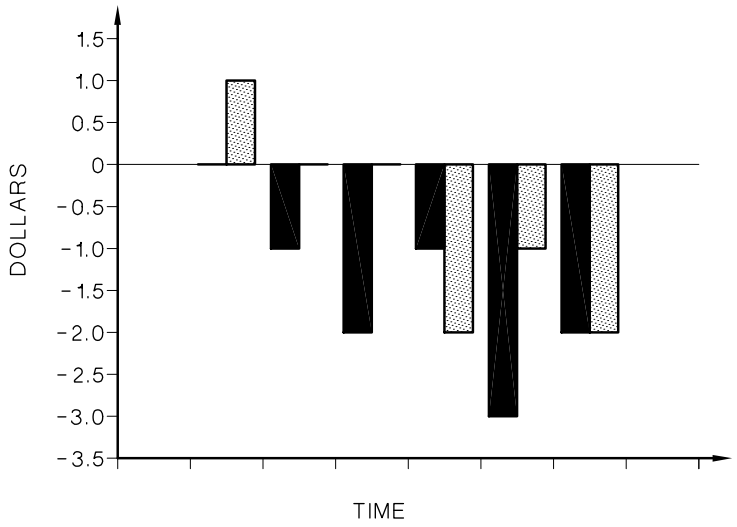


	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Planned Value (PV)	0	10	20	40	70	120	170	240	310	390	470	550	630	700	750	770	780
Earned Value (EV)	0	10	19	37	66	113	161										
Actual Cost (AC)	0	9	18	36	67	115	165										
Project Budget (PB)	900	900	900	980	980	980	980										
Budget at Completion (BAC)	700	700	700	700	780	780	780										
Estimate at completion (EAC)	700	700	710	720	810	820	828										

FIGURE C3 PROJECT X – PAST PERFORMANCE, CURRENT STATUS AND FORECAST

C4 Variance Chart – Period Data

The Chart in Figure C4 presents the SV and CV which occurred in each month. It can be presented in dollar amounts or percentages. This information is of value since current month data is of necessity a leading indicator of cumulative data. However, it is also subject to wide variations. A compromise MAY be reached by plotting and analysing a fixed period moving average.

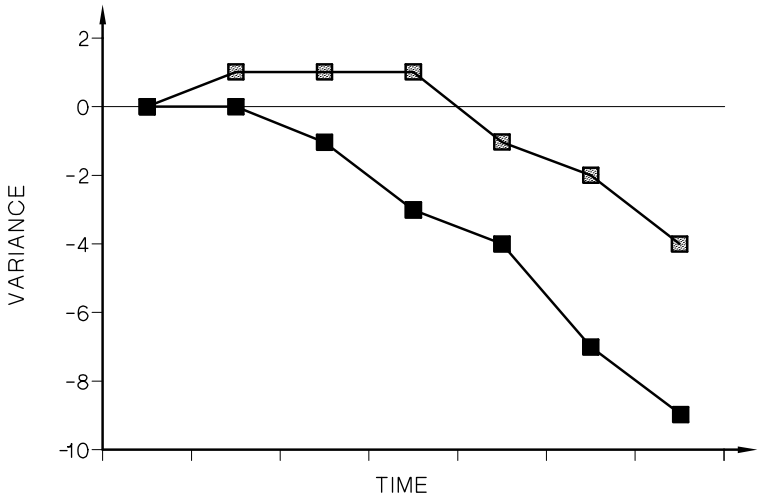


	Apr	May	Jun	Jul	Aug	Sep	Oct
Schedule Variance (SV)	0	0	−1	−2	−1	−3	−2
Cost Variance (CV)	0	1	0	0	−2	−1	−2
Planned Value (PV)	0	10	10	20	30	50	50
Earned Value (EV)	0	10	9	18	29	47	48
Actual Cost (AC)	0	9	9	18	31	48	50

FIGURE C4 PROJECT X – SCHEDULE VARIANCE AND COST VARIANCE

C5 Variance Chart – Cumulative Data

The chart in Figure C5 displays the cumulative SV and CV trends over time.



	Apr	May	Jun	Jul	Aug	Sep	Oct
Schedule Variance (SV)	0	0	-1	-3	-4	-7	-9
Cost Variance (CV)	0	1	1	1	-1	-2	-4
Planned Value (PV)	0	10	20	40	70	120	170
Earned Value (EV)	0	10	19	37	66	113	161
Actual Cost (AC)	0	9	18	36	67	115	165

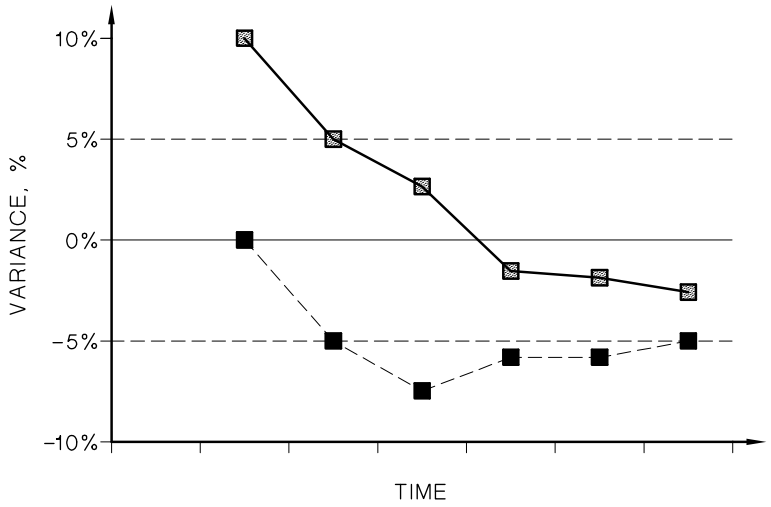
FIGURE C5 PROJECT X – SCHEDULE VARIANCE AND COST VARIANCE

C6 Variance Chart – Cumulative In Percent

Refer to equations in Annex B1.

The graph in Figure C6 displays the trends in SV and CV as a percentage of the respective denominator. Generally, the variances will decrease over time as the denominator increases. During the initial stages of the PROJECT the charts frequently reveal wide variations due to the small value of the denominator.

For reporting purposes it is common to establish thresholds beyond which management attention would be given. Such a threshold is displayed here in Figure C6 at +5% and –5%.



	Apr	May	Jun	Jul	Aug	Sep	Oct
Schedule Variance (SV)	0%	0%	-5%	-8%	-6%	-6%	-5%
Cost Variance (CV)	0%	10%	5%	3%	-2%	-2%	-2%
Planned Value (PV)	0	10	20	40	70	120	170
Earned Value (EV)	0	10	19	37	66	113	161
Actual Cost (AC)	0	9	18	36	67	115	165

FIGURE C6 PROJECT X – SCHEDULE VARIANCE AND COST VARIANCE CUMULATIVE IN PERCENT

C7 'Bull's Eye' Chart

The chart in Figure C7 shows the interaction between SVs and CVs.

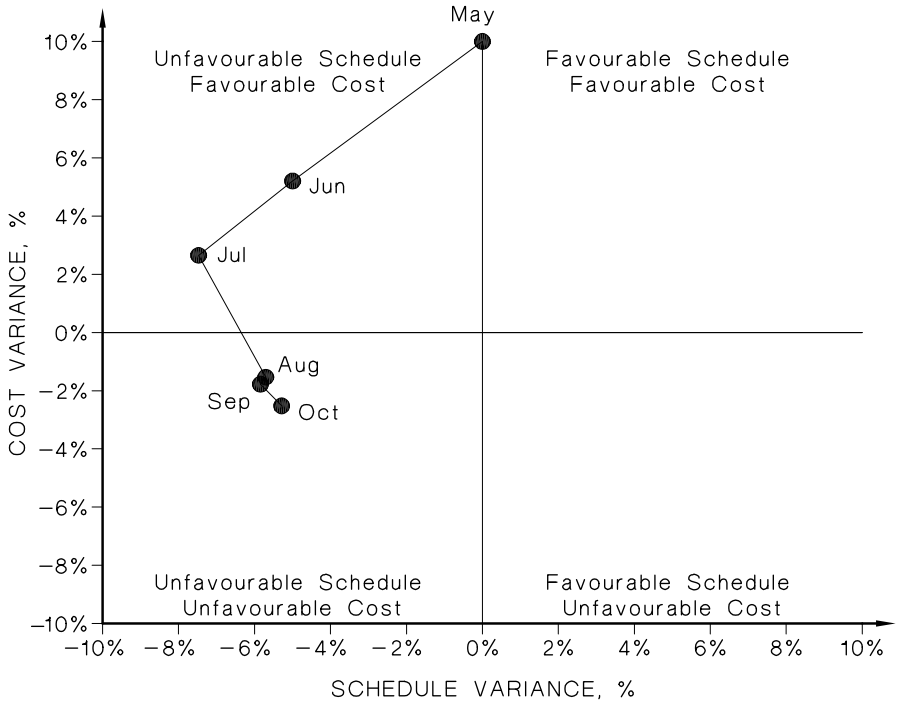
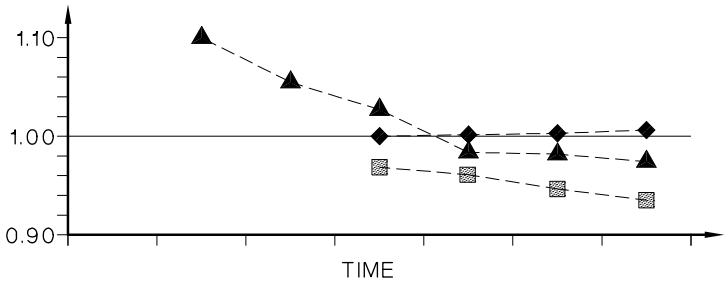


FIGURE C7 'BULL'S EYE' CHART

C8 Efficiency Chart

Refer to equations in Annex B2.

The chart in Figure C8 compares past performance with performance required from now until the end if the target is to be achieved. For example, the chart compares cost efficiency to date, the CPI), with the level of efficiency that must be achieved on the remaining work in order to reach the EAC ($TCPI_{EAC}$) or to meet the BAC ($TCPI_{BAC}$). This information is of use in determining the validity of the PROJECT's EAC or the attainability of the BAC.



	Apr	May	Jun	Jul	Aug	Sep	Oct
Cost Performance Index (CPI)		1.11	1.06	1.03	0.99	0.98	0.98
To Complete Performance Index of EAC ($TCPI_{EAC}$)				0.97	0.96	0.95	0.93
To Complete Performance Index of BAC ($TCPI_{BAC}$)				1.00	1.00	1.00	1.01
Earned Value (EV)	0	10	19	37	66	113	161
Actual Cost (AC)	0	9	18	36	67	115	165
Budget at Completion (BAC)	700	700	700	700	780	780	780
Estimate at completion (EAC)	700	700	710	720	810	820	828

FIGURE C8 PROJECT X – COST PERFORMANCE INDEX TO COMPLETE PERFORMANCE INDEX

C9 Automated Tables

Analysis software tools provide the ability to develop automated graphs and tables. Table C9 contains several mathematical indicators for each WBS element. The Table can be filtered and sorted to display the information in ways to suit the user's need. This example is sorted by the WBS code. It could equally be sorted by the magnitude of the CV for example. The shaded areas (SPI and CPI) indicate whether the value is inside or outside the tolerance thresholds established by the user. The arrows indicate whether the values this period is better (up), worse (down), or unchanged (horizontal) since last period. Table C9 allows the user to quickly sort any column to identify the significant problems.

WBS	WBS Description	Project Officer	% Comp	% Spent	SV	CV	SPI	CPI	SPI	CPI
1	Business Transformation Project		15%	15%	−53	9	0.97	1.01	↑	↓
1.3	Implement Earned Value Performance Management		24%	24%	−53	9	0.97	1.01	↑	↓
1.3.01	Committed Management		96%	110%	−20	−70	0.96	0.87	↔	↓
1.3.02	Business Processes and Procedures		60%	50%	−80	20	0.60	1.20	↓	↑
1.3.03	Management Information System		97%	90%	−3	7	0.97	1.08	↔	↔
1.3.04	Data		45%	45%	50	5	1.13	1.01	↑	↔
1.3.05	Competent and Willing Personnel		0%	0%	0	0	****	****		
1.3.06	Transition to Operation		75%	77%	−50	−3	0.75	0.98	↔	↓
1.3.07	Managed Project		25%	20%	50	50	1.25	1.25	↑	↓

Table C9 Automated Table

C10 Independent Estimates At Completion Chart

The chart in Figure C10 shows the EAC together with the Independent Estimates at Completion (IEACs). In Figure C10 the expressions used for IEAC are as follows:

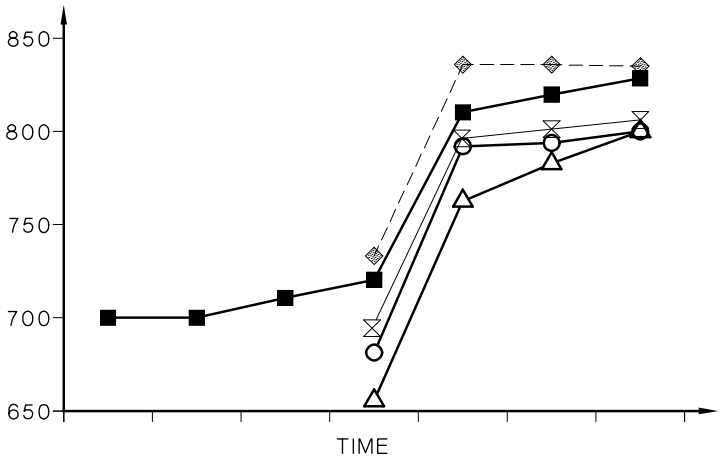
$$IEAC_1 = AC + \frac{(BAC - EV)}{CPI} = \frac{BAC}{CPI}$$

$$IEAC_2 = AC + \frac{(BAC - EV)}{0.8 \times CPI + 0.2 \times SPI}$$

$$IEAC_3 = AC + \frac{(BAC - EV) \times 3}{CPI_1 + CPI_2 + CPI_3}$$

$$IEAC_4 = AC + \frac{(BAC - EV)}{CPI \times SPI}$$

The fact that these expressions are called IEAC1, IEAC2, IEAC3 and IEAC4, in this example does not mean that these are the only formulae used for calculating IEAC, nor that these are the accepted names for these formulae.



	Apr	May	Jun	Jul	Aug	Sep	Oct
Independent Estimate at Completion (IEAC1)				681	792	794	799
Independent Estimate at Completion (IEAC2)				694	798	800	803
Independent Estimate at Completion (IEAC3)				656	764	783	799
Independent Estimate at Completion (IEAC4)				733	836	836	835
Estimate at Completion (EAC)	700	700	710	720	810	820	828

FIGURE C10 PROJECT X – INDEPENDENT ESTIMATES AT COMPLETION

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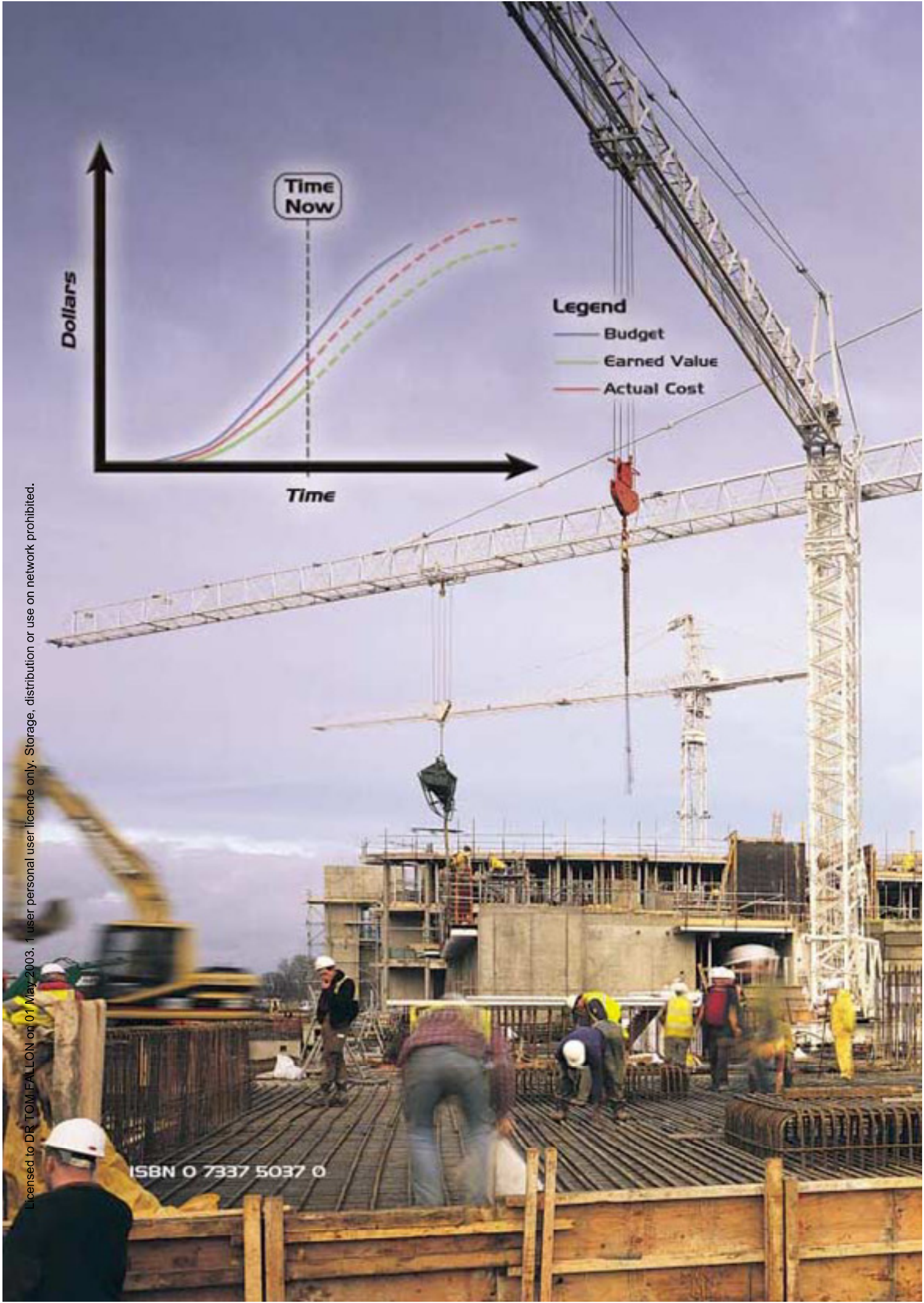

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