Unclassified **NEA/RWM/R(2012)10**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **27-Feb-2013**

English - Or. English

NUCLEAR ENERGY AGENCY

NEA/RWM/R(2012)10
Unclassified

Radioactive Waste Management Committee

COST CONTROL GUIDE FOR DECOMMISSIONING OF NUCLEAR INSTALLATIONS

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JT03335355

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Foreword

This cost control guide was prepared in response to the request from the OECD/NEA Working Party on Decommissioning and Dismantling (WPDD) – Decommissioning Cost Estimation Group (DCEG) to offer the industry guidance in preparing and implementing cost and schedule controls during decommissioning. The DCEG sent out a survey questionnaire in 2010 soliciting comments from OECD member states on their use of cost controls during decommissioning. While the response was limited, the consensus was to proceed with the preparation of this guide.

Cost and schedule control systems have been in use for more than 30 years, and in the last 10 years or so have evolved into a more formalised earned value management system (EVMS). This guide is based on the internationally recognised standard, *Earned Value Management Systems* (ANSI, 2007). The EVMS is built on a work breakdown structure (WBS) of decommissioning activities, and a defined process for controlling a project. The EVMS not only provides measurement of project status and future performance, but also builds a structure and culture for accountability on project performance. This guide describes the performance metrics used to determine the value earned based on what was planned to be done, what was actually accomplished and what it actually cost. Variances measured monthly at a minimum indicate where potential problems are arising and raise a flag for the project manager to implement corrective actions for the next reporting period.

The success of the EVMS programme depends on management commitment to implement a culture change for its employees, and to impose the EVMS on potential future contractors performing decommissioning work at a facility. Formal training is required to ensure all elements of the process are understood and put into action. It is recommended to begin with a small project, and graduate to larger projects as the staff learns how to use the system. The EVMS process has been used internationally for small (less than EUR 20 million) and large (EUR multi-billion) projects successfully. The level of success depends on the commitment to excellence.

Acknowledgement

The WPDD wish to express their gratitude to Mr. Thomas S. LaGuardia for drafting this report.

Table of Contents

List of figures

List of tables

1. Introduction

The introduction describes the objective of this guide, the background for the need of cost and schedule controls, the results of an OECD/NEA cost controls survey questionnaire sent to its member states, the need for a company management culture change to implement controls, a brief discussion of accountability, and the applicability of cost and schedule controls to decommissioning.

Objective

The objective of this guide is to provide a practical, user-friendly approach to implementing cost controls for major decommissioning programmes[1] to minimise project budget and schedule over-runs. The guide establishes the framework for structuring a programme for preparing cost controls, training, certifying and using cost controls through an earned value management system (EVMS).

Background

The technologies for decommissioning nuclear facilities are now well established, and the literature contains many examples of successful projects in completing the removal of radioactivity and termination of the license. However, the cost and schedule performance experience has been wrought with problems stemming from poor and inadequate cost and schedule controls. Many of these problems arose from changes to the technical scope of work, without a corresponding change to the contract documents and budget/schedule modifications to account for these changes. In some cases, the decommissioning contractors were dismissed from the project under duress for failing to meet project milestones of budget and schedule, and the owner/licensees were forced to seek replacement contractors at additional cost and delays to the original schedule. Some of these situations led to extensive litigation, incurring additional legal expenses and further delays. The perception of the public, regulators, stakeholders and interveners is that the overall process is uncontrollable and unpredictable leading to a loss in confidence with the industry.

Over the years of decommissioning experience, the industry has successfully prepared detailed computer cost and schedule estimating codes to develop reliable costs and schedules at the outset of a project, based on a projected technical scope of work and a defined end point condition. The resulting baseline cost and schedules were used to establish owner/licensee budgets and durations for the project upon which to establish decommissioning trust funds, either externally held or internally managed. To encourage consistency and transparency, the Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA), the International Atomic Energy Agency (IAEA) and the European Commission (EC) jointly developed the guide, *International Structure for Decommissioning Costing (ISDC) of Nuclear Installations* (2012). This document (formerly the *Yellow Book*) established a standardised list of cost items to be included in decommissioning cost estimates in a specific format (work breakdown structure – WBS) so as to ensure all elements of costs would be included in a consistent format. By so doing, cost estimates of individual decommissioning activities from various cost estimators and countries could be more readily compared and understood.

The cost and scheduling area that previously had not been adequately addressed is the establishment of technical scope change control, and an effective cost and schedule control system (CSCS) during the implementation of a project. This guide identifies the principles, provides the procedures, structures the training programme and gives specific examples of CSCS implementation.

1. "Programme" will be used herein to describe the entire decommissioning work scope to achieve the end point state. "Project" will be used herein to describe individual major tasks comprising multiple activities.

Cost control survey results

During the period 2009 through 2010, the OECD/NEA conducted a cost control survey of its member states to determine current practices with respect to cost and schedule controls during recent decommissioning projects. The response to the questionnaire was limited (7 out of 34), indicating perhaps many of the member states were not using cost controls effectively, or misunderstood the questionnaire.

The seven respondents indicated many of the elements of a cost control programme existed within their organisations, but were not tied into a cohesive programme to effect accountability in performance. These elements can be blended and incorporated into a comprehensive cost control programme. The most critical element in moving forward is the importance of effecting a culture change within the owner/operator/contractor arena, a feat made much easier with prior evidence of successful cost savings. Intensive training programmes, oversight and their associated costs must be outweighed or at least balanced by the savings achieved.

The survey report noted the industry should not expect immediate success since constructive cost controls will take time to implement. The timetable for any large-scale implementation may be years into the future. The most realistic approach is to start pilot programmes with smaller projects or specific activities within larger ventures. Armed with a new structure of written policies and procedures, several smaller projects could then provide the feedback and lessons learned to develop standardisation and accountability throughout the decommissioning industry.

Cost control culture change

The key to a successful CSCS is effecting culture change within the owner/licensee management organisation, and imposing that culture change on prospective contractors performing the work. This can only be accomplished by an intensive training programme extended to include contractors, coupled with a company-wide publicity programme to encourage excellence. This type of effort has been successfully accomplished with such programmes as Total Quality Management and Six Sigma. But it requires the full commitment of management to financially support and promote it.

Accountability

A key element of a CSCS is accountability of the programme for budget and schedule compliance. Accountability in this context is not intended as a punitive action (although that might be an outcome if there is repeated non-compliance), but rather an evaluation of the causes of non-compliance and the identifications of trends resulting from a breakdown in the system. This feature of a CSCS is a necessary element to measure how effectively the project is being managed, and whether and where improvements are needed.

Applicability to decommissioning

The use of CSCS originated in the construction industry for major projects, where there had been a history of project over-runs in budget and schedule. Over-runs of budget exceeding 100% were not uncommon, and the industry realised it needed a better system to control projects. These same characteristics exist in the decommissioning industry, and perhaps to an even greater extent since the discovery of formerly unidentified radioactive contamination has historically extended scope and costs drastically. Accordingly, a well-defined CSCS is fully applicable to decommissioning projects.

This CSCS guide describes the baseline cost and schedule estimates, the EVMS and its indicators, cost collection and controls, project change control and sources of additional information. It is based on the internationally recognised ANSI standard, *Earned Value Management Systems* (2007).

Site characterisation

Although beyond the scope of this cost control guide, the site and facility to be decommissioned must be thoroughly characterised for radiological and hazardous/toxic materials prior to any planning, cost estimating and scheduling. The characterisation forms the framework for identifying the scope of work to be performed

to achieve the end point of decommissioning. The IAEA published a report on characterisation, *Radiological Characterization of Shut Down Nuclear Reactors for Decommissioning Purposes*, which states:

> *The objective of radiological characterization is to provide a reliable database of information on quantity and type of radionuclides, their distribution and their physical and chemical states. Characterization involves a survey of existing data, calculations, in situ measurements and/or sampling and analyses. Using this database the decommissioning planner may assess various options and their consequences, considering:*
>
> - *operating techniques: decontamination processes, dismantling procedures (hands on, semi-remote or fully remote working) and tools required;*
> - *radiological protection of workers, general public and environment;*
> - *waste classification;*
> - *resulting costs.*
>
> *Comparison and optimization of these factors will lead to the selection of a decommissioning strategy, i.e. typically, immediate or deferred dismantling. It should be noted that the characterization process is sequential in that further steps can be decided only after the results of previous characterization steps have become available.* (IAEA, 1998)

Characterisation data forms the basis for identifying the scope of work for decommissioning, which in turn is used to select the type of contracts to be let to prospective contractors. A well-defined scope of work will permit much of the work to be fixed price (sometimes called lump sum), or cost plus a fixed or incentive fee, or a time-and-materials contract. To the maximum extent possible, fixed-price contracting is preferred as it defers the risk to the contractors rather than the owner/licensee. A well-defined scope of work minimises the opportunities for contract change orders which historically have driven project costs over budget and beyond schedule. Accordingly, no planning, cost estimating or scheduling, or contracted field work should begin until the facility and site have been properly characterised.

2. Cost Estimates and Schedules

The cornerstone of any CSCS is the baseline cost estimate and schedule. At the point when the owner/licensee is ready to contract for the decommissioning work to proceed, a detailed baseline cost estimate and schedule is assumed to have been prepared, based on a reliable data base of a fully characterised facility and known end point condition.

Baseline cost estimate

The development of a baseline cost estimate is an evolving process, as it proceeds from a conceptual stage through a final plant shutdown decision point. Once a decommissioning strategy (immediate dismantling or safe storage, or a combination of both) has been selected, all assumptions, boundary conditions, scope of work and end states should be established, reviewed and approved by management. A decommissioning funding plan is then established and adequate funds are collected or designated to accomplish the project safely and successfully.

The methodology used to prepare the baseline cost estimate can be a company-specific (owner/licensee) computer program, or based on the guide prepared jointly by the OECD/NEA, IAEA and EC, *International Structure for Decommissioning Costing (ISDC) of Nuclear Installations* (2012). The most important element of the baseline cost estimate is formatting the estimate into a WBS. The EVMS depends on this foundation of the WBS for controlling the project.

Baseline schedule

Similarly, the baseline schedule needs to be developed to the same level of detail as the cost estimate, and needs to be integrated as to the period of performance as well as the resources (manpower, equipment and materials) required to accomplish the project on the desired schedule. Commercially available computer codes can be used to develop the schedule, including Primavera's P6 or Microsoft's Project codes. The schedule must reflect the same WBS elements used in the cost estimate, but may be at a higher WBS level than the cost estimate.

Work breakdown structure

As noted earlier, the WBS is the foundation of the EVMS cost control system. The WBS defines the scope of work into appropriate elements for cost accounting and work package authorisation. The WBS must be kept current as scope changes are identified by management, or by physical or technical constraints that evolve as the project proceeds. The WBS is generally associated with the hands-on work to be performed, but may also be used for procurement of major equipment or special tooling where there is a significant expense or design effort to perform an activity.

Project management principles require a WBS dictionary to be prepared for each element of the WBS. The dictionary identifies the scope of work represented by each element of the WBS, and defines the boundaries of responsibilities of the organisation responsible for performing the work.

The ISDC is structured around a WBS, as are most cost-estimating programmes. As the programme progresses from one phase to another, the WBS should be reassessed and modified to reflect the current scope of work and breakdown of costs.

Organisational breakdown structure

The ANSI standard (2007) as well as most other guides recommends establishing an organisational breakdown structure (OBS) for the project. The OBS identifies the management organisation responsible for administering the programme, the specific functional positions required (staffing positions), the subcontracted portions of the programme, and the control accounts to manage the programme.

Management organisation

The management organisation is the owner/licensee staffing assigned to the administrative and technical oversight of the project. It includes the project manager, assistant project manager, administrative managers (security, personnel/human resources, financial/accounting, public relations, janitorial, and others as appropriate), technical managers (engineering and planning, cost and schedule control, licensing, waste management, health physics and radiological, quality assurance, operations and maintenance, and others as appropriate). Below these levels are typically the superintendents in each discipline, who oversee the subcontractor crews performing the work in the field or in the field office.

If the owner/licensee elects to self-perform the field decommissioning work, they may "subcontract" the field work to an in-house division which will provide its own project management staff, with comparable levels as above. The subcontracted group will report to the owner/licensee organisation above.

If the owner/licensee elects to subcontract the field work to an external decommissioning operations contractor (DOC), the DOC will establish its own management staff from its project manager on down through superintendents and foremen to direct the field work.

The ANSI guide (2007) proposes to separate the management organisation from the hands-on work, as most management contracts (or subcontracts) are on a level-of-effort cost basis (that is, the organisation is reimbursed for all its costs plus a fixed or incentive fee). However, this may introduce a potential loss of accountability and another level of complexity to determine whether performance milestones have been met.

Control accounts

The programme establishes the organisational levels at which to implement control accounts. A control account identifies a defined work scope from the WBS system, with accounting charge numbers to track costs. Control accounts are assigned to a single organisational unit and single manager (control account manager). Control accounts may have multiple charge numbers within a WBS element depending on the number of organisations authorised to work within the scope of that WBS element. A control account manager may be assigned multiple control accounts, but each control account will have only one control account manager.

The control account is where the programme (or project) cost, schedule and work scope are integrated, planned and managed. Resources are managed at this level, to accommodate constraints on budget, schedule commitments and availability of manpower and equipment resources. Performance measurement is also made within the control accounts; budget and schedule performance data is reported to management for assessment of meeting programme (or project) objectives.

The size and duration of the control account in terms of the work scope and currency budget is determined by management, based on the WBS logic and importance. For example, one control account may be assigned for removal of fuel from the core and placement in a spent fuel pool or pond for temporary storage before transport for reprocessing. However, if the fuel has to be placed in on-site dry storage casks for prolonged storage until a federal repository is available, a second control account would be assigned for the design, licensing, fabrication, construction and operational readiness of an independent spent fuel storage installation. A control account should not cover more than one WBS element.

Work authorisations

The importance of control of work during decommissioning cannot be understated. Contractors performing field work must not be allowed to proceed without a fully approved work authorisation. Not only from the standpoint of controlling cost and schedule performance, but also for safety to the workers and the public. Fortunately, this practice is universally observed through the process of radiological work permits, confined-space entry permits and other hazardous duty restrictions with associated documentation. The

benefit to the CSCS is a defined cost and schedule control process with oversight from both a radiological and operational management organisation.

Changes in scope resulting from a technical re-direction of objectives, or from a previously undetermined problem must be similarly controlled by approved procedures. No work should be permitted until all necessary approvals are secured and the corresponding budget and schedule performance measurement metrics adjusted. Interim temporary approvals of a revised work scope (with limitations) may be necessary in unusual or safety-related instances, but these should be maintained at a minimum for rigorous control of budget and schedule.

Responsibility assignment matrix

The responsibility assignment matrix (RAM) shows the WBS and OBS, and the integration of the specific responsibilities of each organisation for each specific task. The following example is for the engineering, procurement, fabrication and installation of reactor vessel internals segmentation. Normally these are shown at the lowest level, but are shown at a summary level in Figure 2.1. Working from the budgeted estimates of cost (or duration hours in a fixed-price contract), an example of a contractor's RAM is shown in the table. The cost values are of course fictitious, but representative of the distribution of the budget.

Figure 2.1: Example of a RAM

This example shows how to set up the RAM for one part of the decommissioning process, and illustrates the structure of the relationships. In practice, the process is much simpler as the baseline cost estimate and the schedule baseline estimate provide the cost and duration data for each WBS element. The OBS cross-walk to the RAM is a straightforward process. The WBS in the alpha-numeric format makes preparation of the RAM much easier. The international structure for decommissioning costs (ISDC) provides the framework for the WBS. This is one of the advantages of standardisation of costs and schedules.

Performing dept. manager		Engineering & planning			Procurement	Fabrication	Install & segment	
		Technology	Conceptual design	Detailed design	Purchase mat'ls & contract for fabrication	Fabricate & shop test	Install & test at NPP-1	Segment & package
Engineering dept.	Mr. I. Bergman	300 hrs EUR 45 k	450 hrs EUR 67.5 k	2 800 hrs EUR 280 k				
Purchasing	Mrs. E. Piaf				250 hrs EUR 25 k + EUR 500 k Matl's			
Shop	Mr. A. Segovia					19 200 hrs EUR 1 920 k		
Field team	Mr. M. Mastroianni						7 200 hrs EUR 1 080 k	10 400 hrs EUR 1 560 k

3. Budget Management

Managing the budget is the principal objective of cost and schedule controls, to ensure that the decommissioning funds collected and approved are used effectively to safely decommission the facility. If budgets are misused and over-run there is the potential for management to take risks to reduce costs, which could result in safety issues to workers and the public. Therefore, management of the budget through cost and schedule controls is vitally important to a safe and effective decommissioning programme.

Performance baseline

The programme budget is a living management tool throughout the life of the programme. The budget is initially linked directly to the baseline cost and schedule estimates, as well as through the negotiated contracts and internal management objectives. The performance baseline (PB – also called the total project cost) is made up of the contract budget base including profit/fee and contingency. Profit/fee is set aside and earned by the contractor as it successfully completes portions of the project. These relationships are shown in Figure 3.1.

Contingency is held by the owner/licensee to apply as needed for the project. Contingency is defined by the AACEI as "a specific provision for unforeseeable elements of cost within the defined project scope, particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events that increase costs are likely to occur" (Humphreys, 1984). Based on experience contingency costs are incurred virtually daily as the project proceeds. All contingency money is expected to be spent, as has been the actual experience in most decommissioning projects.

Contract budget base

The contract budget base (CBB) consists of the management reserve, the performance measurement baseline and the contractor's profit or fee.

Management reserve

All baseline cost estimates (below the performance measurement baseline level described in the next section) include management reserve (which is different than contingency), which will be withheld by the contractor before the budget is distributed to lower accounts (the contractor may refer to its management reserve as its contingency). Management reserve is established by the contractor's project manager and held for unexpected costs within the currently authorised scope of work, rate or inflationary changes (not previously accounted for), and other programme unknowns. The programme budget will be revised as programme, scope and schedule changes are authorised. For long-term programmes, economic price adjustments must also be made to account for inflation.

Performance measurement baseline

The performance measurement baseline (PMB) is the level at which the programme performance is evaluated. It consists of the distributed budgets and the undistributed budgets. The distributed budgets represent the hands-on work of decommissioning activities. The undistributed budgets are for future work that has not been planned sufficiently to include in the distributed budgets.

Distributed budgets

Distributed budgets are made up of numerous control accounts for hands-on work consisting of work packages and planning packages. Control account performance is rolled up to the distributed budget level for reporting purposes.

Undistributed budget

An undistributed budget consists of funds not allocated either to distributed budgets or to management reserve. Undistributed budgets are funded, and represent known work that must be performed but not planned to the same detail as distributed budgets. Undistributed budget should be allocated as quickly as practicable by the control account manager (described in the next paragraph) into the distributed budget. As soon as the scope of work is described, a detailed plan is prepared, and costs and schedules estimated, the task would be transferred to the distributed budget.

Control accounts

Control accounts consist of numerous decommissioning activities described in work packages and planning packages. A control account manager is assigned to each control account (one manager to each account), but a single manager may have the responsibility for several control accounts. The control account manager evaluates the progress of each work package and planning package in the account, and determines the amount of physical work performed during each reporting period. Often, the control account manager will work with the contractor's project manager to negotiate the work completed or per cent completed.

Work packages

Work packages are subdivisions of control accounts, and are comprised of a single or multiple groupings of tasks. It can apply to single or multiple organisations and functions.

A work package is the level at which the field work is planned and progress is measured. According to ANSI/EIA-748-B (2007), the work package level is where earned value is computed. Other standards recommend the performance measurement baseline (PMB) as the preferred level for computing earned value.

Planning packages

Planning packages are for far-term activities within the control account. The budgets for planning packages are time-phased to the known schedule for future work. Planning packages are converted to work packages as the project proceeds.

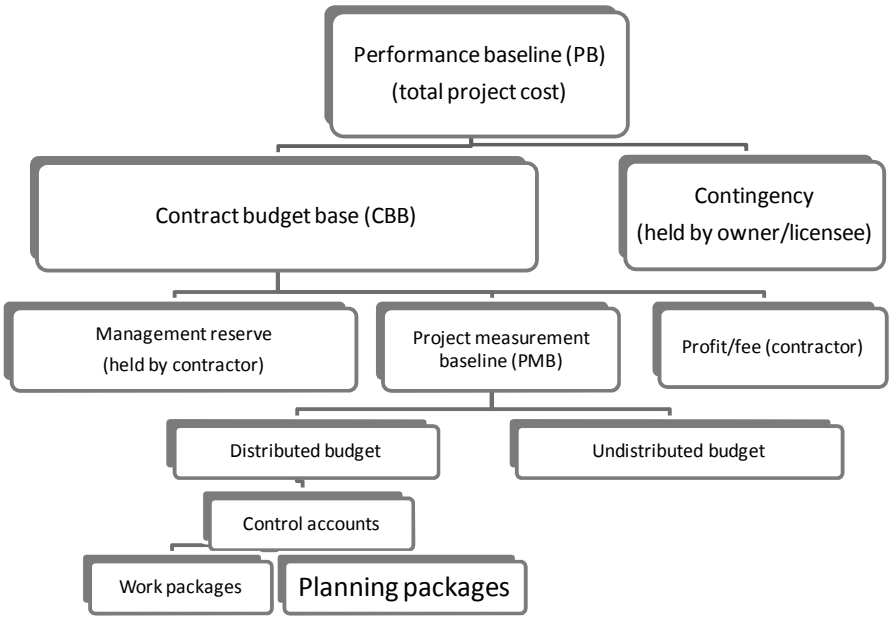
Performance measurement baseline components

The performance measurement baseline (PMB) is the total time-phased budget for the programme. It is the summation of all budgets of the control accounts (distributed budgets) and undistributed budgets. As noted earlier, the PMB is the level at which earned value is calculated. The components of the PMB include the following:

PB	= CBB + contingency	= performance baseline (TPC, total project cost)
Contingency		= held by owner/licensee (or contractor)
CBB	= PMB +MR + P/F	= contract budget base
PMB	= DB + UB	= performance measurement baseline
WP		= work package (near-term, activities within a CA)
PP		= planning package (far-term, activities within CA)
MR		= management reserve (held by contractor for risks)
P/F		= contractor's profit or fee
DB		= distributed budget
UB		= undistributed budget (not yet distributed to CA)
CA	= WP + PP	= control account (to the lowest WBS assigned)

Figure 3.1 shows a chart of the PMB hierarchy.

Figure 3.1: Performance baseline components



4. Earned Value Management System Description

The EVMS is a programme that evolved over many years in the construction and manufacturing industries in response to continual project budget and schedule over-runs. It has been adopted and endorsed by most of the internationally recognised standards organisations, including the Association for the Advancement of Cost Engineering International (AACEI), the Project Management Institute (PMI), the American National Standards Institute (ANSI) and the United States Department of Energy (US DOE), among others. The concepts described herein are relatively easy to understand, but require a significant management culture change and a diligent effort to implement in the field. The only effective way to launch the system is through a comprehensive training programme, coupled with a company-wide commitment to excellence.

EVMS purpose

EVMS is an integrated set of policies, procedures and practices to support programme and project management as a decision-enhancing tool and a critical component of risk management. An EVMS:

- Effectively integrates a project's work scope, cost and schedule into a single PMB.
- Reliably tracks:
  - planned value (PV) of work to be performed, or the budgeted cost for work scheduled (BCWS);
  - earned value (EV) of actual work performed, or the budgeted cost for work performed (BCWP);
  - actual cost (AC) of work performed (ACWP).
- Provides performance measures against the PMB.
- Provides means of identifying, reviewing, approving and incorporating changes to the PMB.
- Provides trend analysis and evaluation of estimated cost at completion.
- Provides a sound basis for problem identification, corrective actions and management re-planning.

Applications

The EVMS should be implemented as early as possible in a project's life cycle. It should be used before any critical programme decisions are made so that it will include the performance baseline (including the contractor's PMB), and must cover the entire programme life cycle. It is ideally suited for cost plus fixed fee, cost plus percentage fee or cost plus incentive fee contracts.

The US DOE document *Earned Value Management System (EVMS)* (2012) requires the use of the EVMS for programmes with a total cost project greater than or equal to USD 20 million (about EUR 16 million). There is no actual limit of programme value, low or high where the EVMS can be successfully used except for very short projects of only a few months duration. In fact, for initial training purposes a small programme or project (USD 5 million, or EUR 3.9 million) can be used effectively.

In the past, the EVMS was not invoked for fixed firm-price contracts because of the contractor's reluctance to share financial information of a proprietary nature. However, recent work has shown that an equivalent EVMS can be used by substituting time instead of currency. On a fixed firm-price project, the focus will be on schedule performance. Schedule performance is planned, tracked and reported in terms of value expressed in time periods. This protects the contractor's proprietary information while still controlling the project. An example of this application is shown in Chapter 5 (see the sub-section entitled *Examples*).

Communications and staff training

When management adopts the EVMS programme, it must be communicated to the entire affected staff as a measure to control costs and schedule. Announcement of the programme can be initiated using a formal letter from top management, then followed up with posters distributed throughout the office buildings and cafeterias, with perhaps a short series of talks during lunch breaks to call attention to the adoption of the EVMS. Similar communications programmes were used in the introduction of the Six Sigma[2] programme in the mid-1990s to build support for the programme among employees.

Communications to potential or existing contractors is equally as important to notify them of what will be expected relative to their work performance on a project. Potential contractors might be invited to participate in the training sessions described in the next paragraph, at their expense, or require them to seek independent training programmes at another venue. In either case, the message must be conveyed that the EVMS will be imposed and implemented with the contractor's performance (and payment) dependent on the work product delivered.

Staff training is a critical part of communicating and implementing the EVMS. It must cover the full spectrum of functional managers on a decommissioning programme, including the programme manager down through the organisational breakdown structure to where the work is implemented. Financial managers, contracts personnel, procurement personnel, cost and schedulers, control account managers, engineering and planning, operations and maintenance, waste management, radiological health and safety, health physics, etc., must all be trained on the EVMS so they understand the inter-relationships involved with their actions on the overall programme. Attached to this guide are sample training sessions that may be used for this purpose (see Appendix C). Other references for training programmes and certification (discussed below) are available. Executive management should also be provided summary level training sessions to understand the controls and constraints imposed on the workings of the organisation.

Certification of the system

Certification of EVMS training is a valuable part of implementing the system into programmes. The certification process ensures compliance with internationally recognised standards, and permits contractors to move from one contract to another without having to retrain its staff. It also allows owner/licensee companies to pre-qualify contractors as prospective bidders, and to evaluate the quality of the readiness of a prospective contractor to begin field work.

The US DOE G-413.3-10a requires a contractor to employ an EVMS in accordance with ANSI/EIA-748-B on projects greater than or equal to USD 20 million (EUR 16 million) by Critical Decision Point 2 and certification no later than Critical Decision Point 3. The DOE Critical Decisions Points are as follows:

- CD-0 – Approve mission need.
- CD-1 – Approve alternative selection and cost range.
- CD-2 – Approve performance baseline.
- CD-3 – Approve start of construction.
- CD-4 – Approve start of operations or project completion.

US DOE certification applies to:

- projects with a total project cost of USD 20 to 50 million (self-certification by the contractor);
- projects greater than USD 50 million (must be certified by the DOE Office of Engineering and Construction);
- new contractors who have replaced contractors with a certified EVMS, or who require certification.

2. Six Sigma is a business management strategy originally developed by Motorola in 1986, which became well known after Jack Welch made it a central focus of his business strategy at General Electric in 1995. Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimising variability in manufacturing and business processes.

Criteria for certification

The criteria for certification are contained in ANSI/EIA-748-B, and should also be in the contract documents. Additional clarification is contained in the *Earned Value Management Systems Intent Guide* prepared by the Programme Management Systems Committee of the National Defense Industrial Association (NDIA, 2011).

5. Earned Value Management Indicators

The EVMS methodology relies on determining earned value through the calculation of cost and schedule indicators, and computing cost and schedule variances to determine the health of a programme (or project). The determination of earned value will depend on the type of effort, whether it is discrete, apportioned or level-of-effort. The calculations are relatively simple, and the means of reporting and collecting the information is readily available through the use of modern accounting software. The system requires the diligence of management to implement all its aspects and to hold the programme (and personnel) accountable for variances that exceed pre-determined limits. The indicators identified herein are included in the ANSI/EIA-748-B guide (2007), and are internationally accepted by project management professionals.

Discrete effort

There are three earned value techniques applicable to discrete work packages (with defined scope and objectives that can be scheduled, and on which progress can be measured). They are valued milestones, standard hours and management assessment. Variations are possible and quantitative formulas can be used to compute earned value for work in progress.

"Valued milestones" require the allocation of budget to specific work objectives (scheduled milestones). Value is earned as the milestones are completed. The milestones must be meaningful points of accomplishment and directly relatable to accomplishing the overall objective of the work package. For example, a milestone for "inspecting and testing the fuel building overhead crane" would not be applicable to transferring fuel from the pool to dry storage.

"Standard hours" are generally applicable to manufacturing accounts, where the budget is time-phased to the standard hour plan. Value is earned in proportion to the standard hour status as earned standards are sold in the shops. As this is not generally applicable to decommissioning, no further discussion will be included.

"Management assessment" may be used to determine the percentage of work completed for a task, a group of tasks or an entire work package. Value is then calculated by applying that percentage to the total budget for that work. For example, a bi-weekly (every two weeks) assessment may be made of the number of meters of piping removed compared to the total amount in the work package, so that the contractor can receive partial payment to pay his crews. This is common practice in decommissioning work, and negotiations in the field between the control account manager and contractor superintendent(s) can be controversial. The value of the EVMS is that if a contractor overstates what piping he has removed in one reporting period, the next reporting period may be more difficult for earning partial payment.

Apportioned effort

Apportioned effort is work for which the planning and progress are linked to other efforts. The budget for the apportioned account will be time-phased in relation to the resource plans for the base account(s). Status and earned value are driven by the status on the base accounts. If the base account is on schedule, the apportioned account will be on schedule and an appropriate amount of value will be earned.

Level of effort

Level of effort (LOE) is work scope or expense of a general or supportive nature for which performance cannot be easily measured. Resource requirements are represented by a time-phased budget, scheduled in accordance with the time that the support will be needed. Value is earned by the passage of time and is equal

to the budget scheduled in each time period. The performance indicator is simply a comparison of budget to actual cost. An LOE is generally used for staff management where the staff functional positions are fixed for several months in a decommissioning period, and the monthly cost is the staff's payroll, overhead, general and administrative expenses, and other costs. Utilities (electricity, telephone, trash services, etc.) would also be handled in this manner. LOE cost estimating for discrete work (piping and component removal, structure demolition, etc.) is not recommended as there is no measurable indicator of progress or accountability.

Performance indicators and measurement

Earned value is determined from indicators of the quantity of work completed, computed on the basis of the resources assigned to the completed work scope as budget. It is related to but not directly linked to the quality of the work performed or the technical approaches used, as a poorly planned task using inefficient techniques will undoubtedly result in excessive costs and schedule slippages. The planning and techniques used for a task are controlled by the quality assurance programme and the detailed technical review of the engineering/planning organisation.

EVMS basic components

The following EVMS components are the building blocks of the calculations needed to determine earned value. All subsequent calculations are based on the data using these values. The process is quite simple, and as noted earlier most modern accounting software can readily provide the information needed and make all necessary computations. In particular, the Deltek Cobra accounting software (Deltek, 2013) is widely used by US DOE contractors as the "gold standard" programme. Most other accounting software companies offer modules to perform the same functions.

PV	= planned value	= BCWS	= budgeted cost for work scheduled
			= what was planned to be done
EV	= earned value	= BCWP	= budgeted cost of work performed
			= what was done at budget rates
AC	= actual cost	= ACWP	= actual cost of work performed
			= what was paid for the work
BAC	= cumulative PV	= cumulative BCWS	= budget at completion
			= original budget plus changes
EAC	= estimate at completion		= the actual cost to date plus an objective estimate of costs for the remaining authorised work

Calculations based on PV, EV and AC may be based on various time periods, i.e. monthly, cumulative, last three months (quarter), etc. The next section of this guide describes how to collect the data needed to calculate these performance parameters.

Variances

Variances are a measure of the project over-run or under-run, indicating the degree the project is either over or under cost and schedule.

CV	= EV – AC	= BCWP – ACWP	= cost variance
SV	= EV – PV	= BCWP – BCWS	= schedule variance
CV%	= (EV – AC)/EV	= (BCWP – ACWP)/BCWP	= cost variance, percentage
SV%	= (EV – PV)/PV	= (BCWP – BCWS)/BCWS	= schedule variance, percentage
VAC	= BAC – EAC		= variance at completion

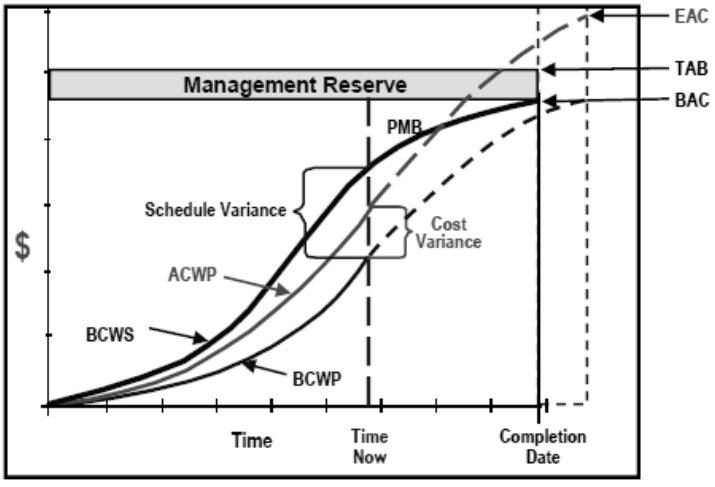
Cost and schedule variance are usually given an action range of acceptability wherein an explanation for over-run or under-run is explained in a statement of the problem, cause and corrective actions planned or taken to bring the specific activity into conformance. This variance analysis is self-correcting in that overstatement of a correction is accountable within the next reporting period. That is, if the proposed correction is insufficient, the following reporting period will show a continuing variance, and additional correction will be required. A positive cost and schedule variance and an index of 1.0 or greater indicate favourable performance. The project manager will usually establish currency, man-hour, or percentage thresholds requiring variance analyses. The thresholds may be based on the year-to-date BCWS, as follows:

BCWS < USD 250 000: %CV = (BCWP – ACWP) × 100 ÷ BCWP= ±10% and $CV = (BCWP – ACWP) = ± USD15 000 %SV = (BCWP – BCWS) × 100 ÷ BCWS = ±10% and $SV = (BCWP – BCWS) = ± USD 8 000
BCWS ≥ USD 250 000: $CV = (BCWP – ACWP) = ± USD 25 000 $SV = (BCWP – BCWS) = ± USD 15 000

Note: These percentages and dollar values are for illustrative purposes and do not represent recommendations. The management organisation must establish the thresholds and ranges of variability for each project.

Calculations based on PV, EV and AC are computed monthly, cumulative, or last three months (quarter), etc. Available accounting computer codes incorporate the ability to calculate these metrics for management review. Figure 5.1 shows the relationship between BCWP, BCWS and ACWP, and the schedule and cost variances where "TAB" is the total allocated budget (contract budget base).

Figure 5.1: Earned value management relationship



Overall status

The overall status of a programme (project) can be evaluated using the following metrics:

% scheduled	= PV_{cum}/BAC	= $BCWS_{cum}$/BAC	
% complete	= EV_{cum}/BAC	= $BCWP_{cum}$/BAC	
% budget spent	= AC_{cum}/BAC	= $ACWP_{cum}$/BAC	
WR	= BAC – EV_{cum}	= BAC – $BCWP_{cum}$	= work remaining
BR	= BAC – $ACWP_{cum}$	= BAC – $ACWP_{cum}$	= budget remaining

Performance indices

Performance indices provide a calculated index of cost and schedule performance.

CPI	= EV/AC	= BCWP/ACWP	= cost performance index
SPI	= EV/PV	= BCWP/BCWS	= schedule performance index
$TCPI_{BAC}$	= WR/BR		= to complete performance index, BAC
$TCPI_{EAC}$	= WR/ETC		= to complete performance index, EAC (where ETC is the estimate to complete)

If the CPI result is less than 1.0, the cost is greater than budgeted; if the result is greater than 1.0, the cost is less than budgeted. If the SPI is less than 1.0, the project is behind schedule; if it is greater than 1.0, the project is ahead of schedule.

Completion estimates

Completion estimates provide a calculated estimate at completion.

EAC	= BAC/CPI_{cum}	= estimate at completion, general
		= actual cost plus estimate to complete
EAC_{cum}	= AC_{cum} + WR/CPI_{cum}	= estimate at completion, CPI
$EAC_{composite}$	= AC_{cum} + WR/($CPI_{cum} \times SPI_{cum}$)	= estimate at completion, composite
LRE		= latest revised estimate (contractor's, assessed monthly, annual bottom-up)
ETC	= EAC – AC_{cum}	= estimate to complete

Performance measurements using the SPI and the critical path (CP) total float (TF) is another way to monitor project performance. Total float is the total time an activity can be delayed on a project without delaying the end date of a project.

TF > 0	
SPI > 1.0	Ahead of schedule on CP; more work being done than planned
SPI = 1.0	Ahead of schedule on CP; some shortfall in work on non-critical activities
SPI < 1.0	Ahead of schedule on CP; significant shortfall in work on non-critical activities
TF = 0	
SPI > 1.0	CP on schedule; more work being done on non-critical activities than planned
SPI = 1.0	CP on schedule; total work volume as planned
SPI < 1.0	CP on schedule; shortfall in work on non-critical activities
TF < 0	
SPI > 1.0	CP activities behind schedule; total work more than planned, indicating excess attention to non-critical activities
SPI = 1.0	CP activities behind schedule; total work volume as planned, indicating too much attention to non-critical activities
SPI < 1.0	CP activities behind schedule; total work less than planned, need more overall effort

Examples

A simplified example of an earned value *cost* performance analysis is shown in Table 5.1. The costs reflect two persons each working at a rate of EUR 100 per hour, eight hours per day, for a total of EUR 1 600 per day. The current period for "design" shows no costs for the period, but the cumulative to date shows the BCWS, BCWP and ACWP at EUR 32 000 each indicating this is a completed activity on budget and schedule so the variances are 0.

Another example of an earned *schedule* performance analysis for a fixed- price contract using time instead of cost is shown for comparison in Table 5.2. The schedule data shown in *days* reflect two persons each working eight hours per day. The current period for "design" shows no work performed for the period, but the cumulative to date shows the BCWS, BCWP and ACWP at 0, each indicating this is a completed activity on budget and schedule so the variances are 0.

This type of schedule performance analysis is intended for firm fixed-price contracts, where the contractor's costs are considered proprietary and not to be shared. In this case as schedule is the primary focus of the project manager, the same type of EVMS controls can be put in place using time instead of costs.

Table 5.1: Example of cost performance data

Item – WBS element	Current period					Cumulative to date					At completion		
	Budgeted cost		ACWP	Variance		Budgeted cost		ACWP	Variance				
	BCWS	BCWP		Schedule	Cost	BCWS	BCWP		Schedule	Cost	Budgeted	Estimated	Variance
1.1 Design	0	0	0	0	0	32 000	32 000	32 000	0	0	32 000	32 000	0
1.2 Develop	0	0	1 600	0	(1 600)	80 000	80 000	90 000	0	(10 000)	80 000	90 000	(10 000)
1.3 Implement	0	3 200	1 600	3 200	1 600	48 000	44 800	57 600	(3 200)	(12 800)	48 000	62 400	(14 400)
Total	**0**	**3 200**	**3 200**	**3 200**	**0**	**160 000**	**156 800**	**179 600**	**(3 200)**	**(22 800)**	**160 000**	**184 400**	**(24 400)**

Table 5.2: Example of schedule performance data

Item – WBS element	Current period					Cumulative to date					At completion		
	Budgeted cost		ACWP	Variance		Budgeted cost		ACWP	Variance				
	BCWS	BCWP		Schedule	Cost	BCWS	BCWP		Schedule	Cost	Budgeted	Estimated	Variance
1.1 Design	0	0	0	0	0	20	20	20	0	0	20	20	0
1.2 Develop	0	0	1	0	(1)	50	50	60	0	(10)	50	60	(10)
1.3 Implement	0	2	1	2.0	1.00	30	28	36	(2)	(8)	30	39	(9)
Total	**0**	**2**	**2**	**2**	**0**	**100**	**98**	**116**	**(2)**	**(18)**	**100**	**119**	**(19)**

6. Cost Collection and Controls

Cost collection and controls are the programme (project) data collected and used to determine the earned value. In decommissioning it is a combination of project accounting reports and field inspections of individual activities to determine percentage complete of a task for invoicing purposes. Accounting software will provide all the necessary data to analyse EVMS management indicators. The control account manager or designee must walk down the work performed or negotiate with the contractor to determine the percentage of work completed in a work package for each reporting period.

Cost reporting and collection

The key data needed for the bi-weekly or monthly reporting period are the BCWS, BCWP and ACWP as described earlier. If the owner/licensee is self-performing the decommissioning work, collection of this information is relatively easy, as the project manager (or his designee) working with the control account manager can extract the data from the control accounts. A decision must be made as to the monetary level (dollars or euros) or milestone breakdown for each work package to facilitate reporting and control. These decisions are generally determined from the project's natural breakpoints, as determined by the WBS.

If the work is subcontracted to a decommissioning operations contractor, the same process is followed by the contractor, subject to the owner/licensee project manager approval. For a cost plus fixed fee, cost plus percentage fee or cost plus incentive fee contract, the process is one of simple negotiation.

However, on a firm fixed-price contract the contractor is not required to share that level of detail for proprietary reasons. Since the contractor bears the risk, the contractor also has the responsibility of project controls. But as experience has taught us, contractors can declare bankruptcy or even abandon the project, leaving the owner/ licensee to call the contractor's bond if one was required and provided, or to find a replacement contractor (usually at a significantly greater cost). The delay to the project and additional expense is untenable. In this case, recent guidance has shown that the contractor can still provide an EVMS if time is used as an earned value indicator instead of a currency measurement. In a recent article in *AACEI Cost Engineering* magazine, author Carol J. Christensen-Day (2010) described the process. Within the control account breakdown, the following substitutions can be made:

BCWS	= planned duration	=	duration for that group of work packages
BCWP (EV)	= earned schedule	=	time at which the amount of earned value accrued should have been earned, including the number of complete periods plus any incomplete portion
ACWP	= actual time	=	number of periods executed
SV	= schedule variance	=	BCWP – ACWP
SPI	= schedule performance index	=	BCWP/ACWP
EAC	= estimate at completion	=	BCWS/SPI
VAC	= variance at completion	=	BCWS – EAC

Note that the aforementioned period values would be in units of time (days, weeks or reporting periods). This approach protects the contractor's proprietary cost information, but provides the owner/licensee and the contractor with a measure of earned value and health of the project. Both parties therefore benefit from this process.

Labour

Labour costs would be entered in the accounting software for each labour category. Work authorisations would indicate the appropriate labour classifications expected to be used on the work package, and associated charge numbers assigned to each individual. For the distributed budgets (hands-on work), the labour costs could be accrued bi-weekly, as the owner/licensee or contractor would need to invoice for its costs so payroll and other expenses could be paid.

For management staff costs, labour would be similarly accrued bi-weekly using the accounting software system. As these costs are usually level-of-effort, they may be accounted for by its appropriate WBS but reported in a separate account as it is a repeating bi-weekly or monthly expense for each phase of decommissioning.

Materials

The costs of materials in decommissioning are of two basic types: consumables and special equipment. Consumables such as small tools, cutting gases, plastic wrap, plastic bags, etc., are reported bi-weekly. Major pieces of equipment may be rented, leased or purchased for the project. They too would be reported bi-weekly. Specially designed equipment, such as remotely operated underwater cutting tools or a robotic arm, would likely be treated as its own control account within the appropriate WBS element for the work packages. Reporting would be bi-weekly or monthly, as procurement, design, fabrication, installation and operational readiness proceeds.

Storage/disposal

Storage and disposal costs will undoubtedly have their own WBS elements and control accounts. Storage may require on-site storage canisters (such as spent fuel dry storage casks), inter-modal containers and a temporary holding area until shipped off-site or to a storage contractor. Costs for transportation would be similarly handled through a WBS sub-element with its own control account. Reporting would be bi-weekly or monthly.

Capital expenditures

Capital expenditures would include construction of a spent fuel storage facility and its security and surveillance system, or an on-site waste handling and temporary storage building. In some cases, the existing security access facility may not be large enough to handle the increased number of personnel from external contractors on site, and a new facility may be needed. These examples would be handled as capital expenditures and have their own control account. Reporting would be bi-weekly or monthly.

Control account and work package completion computation methods

On most large projects like decommissioning, individual tasks (work packages) extend over several months. Determining the earned value can be a challenge in some cases if the scope of work in the package is not well defined. There are a number of methods available to accomplish this, including:

- fixed formula;
- milestone weights;
- milestone weights with per cent complete;
- units complete;
- per cent complete;
- level of effort.

Fixed formula

The fixed formula method applies to work packages and control accounts that span a short period of time (within an accounting period of say less than three months). This method applies a per cent complete to the start and finish of an activity. Generally, the percentages used in the formula are 0/100, 50/50 or 25/75%. Under the 0/100 formula, nothing is earned when activity starts but 100% of the budget is earned when it is completed. With the 50/50 formula, 50% is earned when an activity starts and the balance is earned on completion. With the 25/75 formula, 25% is earned when the activity starts and the balance is earned on completion.

Milestone weights

The milestone weighting method assigns budget value to each milestone. Upon full completion of each milestone the budget is earned. This method is used for work packages with long durations and ideally should have milestones each month or accounting period. Nothing is earned until the milestone is completed, which means the contractor will receive no credit (payment) until the next or subsequent period. For the contractor, it creates payroll problems unless the contractor has many other work packages in progress with successfully completed milestones. For the project manager, it simplifies determination of earned value as no judgmental or uncertainty is involved. However, it requires well defined milestones, which is a small price to pay to keep a project under budget and on schedule.

Milestone weighting with per cent complete

Milestone weighting with per cent complete assigns budget value to each milestone, and is earned based on the per cent of work completed against each individual milestone. This method is used for work packages with long durations and should have milestones each month or accounting period. The per cent completed may be determined on the basis of material removed for the milestone. For example, if the milestone is to remove all the piping from a given work area, amounting to say 500 meters of piping, the control account manager (or his designee) will work with the contractor's project manager to estimate the amount of pipe actually removed during the reporting period. If 70% is removed, the contractor will have earned 70% of the value of the milestone, or the value of 350 meters of pipe.

There is always some amount of negotiating involved to reach agreement, but if the contractor overestimates the per cent removed the contractor will have to make it up during the next reporting period with no additional payment. The contractor will have to explain in its progress report why he missed the milestone and what will be done during the next period to regain schedule. This is where accountability plays an important role in earned value.

Unit(s) complete

The unit complete method uses a physical count to determine what is earned. To use this method, there must be units that are identical or similar, and they must have the same budget value. For example, if a work area contains 10 tanks of approximately the same size and complexity (and cost) for removal, the value will be earned when all ten tanks have been removed. If only five tanks are removed during a reporting period, the contractor will get credit for only 50% of the earned value. The same consequences are faced by the contractor as in the previous example, with an explanation required of why the contractor missed the milestone and what will be done during the next reporting period to make up the delay in schedule.

Subjective per cent complete

The subjective per cent complete method applies a per cent compete to a budget value to determine what is earned. The per cent complete value is determined by the control account manager (or his designee) and the contractor. The method might apply for the preparation of detailed procedures needed for a subsequent activity. The amount of work for each procedure might vary with complexity, or may depend on the project manager's approvals needed for acceptance. Another situation may arise where the contractor's work depends on the availability of a major crane that is also being used by other contractors with higher priorities. The subjective decision as to per cent complete may be a negotiated amount each reporting period. The control account manager must maintain documented logic of the method used for each reporting period. Milestones generally do not apply for this method.

Level of effort

The level of effort (LOE) method is based on the passage of time. A monthly budget value is earned with the passage of time and is always equal to the monthly planned amount. When using LOE, the planned value (BCWS) is always equal to the earned value (BCWP). The earned value would be the same for each reporting period, and the per cent complete would be the per cent complete for that phase. The actual cost (ACWP) would be determined from the accounting records. For example, programme (or project) management would depend on the management staffing level for a phase of decommissioning. The contractor's (or owner/licensee's) staff costs are fixed for the periods of phase, and the contractor (or owner/licensee) would earn the full value for that reporting period. The only challenge would be whether the size of the staff is needed for that phase. This is generally agreed upon early in the project so that monthly or periodic negotiations are unnecessary. This earned value method should be kept to a minimal number of work packages.

7. Change Control

The performance measurement baseline is the time-phased budget plan against which contract performance is measured. Measurement data require a documented PMB that accounts for the most current conditions of the programme. Once the PMB is established or "frozen", cost and schedule changes are processed through formal change control procedures. Authorised changes must be incorporated into the PMB in a timely manner and reflected in both budgets and schedules. A change control process is used to establish, analyse, communicate and record approved changes to the programme baseline.

Identification of scope changes

As noted earlier, scope changes are the largest cause of cost and schedule over-runs. If scope changes are not identified early and adjustments made to the budget and schedule immediately, the programme and projects can get out of control. The effect on management performance, credibility and reputation can be devastating. Relations between the owner/licensee and the contractor can become adversarial when there is not a clear understanding of scope changes, adjustments to budgets and contracts, or schedule extensions. Adversarial relationships often end in litigation and incur additional expenses.

For any type of contract, be it cost plus fixed or incentive fee, firm fixed-price and even time and materials contracts, a clear identification of scope is imperative to good management principles and practices. As has been stated in numerous other articles, conferences, meetings and guidance documents, early radiological and hazardous materials characterisation must be performed before a contract is awarded. This means the owner/licensee has the responsibility to perform the characterisation work (or contract for it to be done) and to distribute the resulting report to all potential bidders. In one case, the owner/licensee invited prospective bidders in to specify those areas of the facility for which they needed characterisation data, and that data was made available to all bidders. The contract was tendered with the understanding that any subsequent contamination found on the site would be the responsibility of the contractor. This approach threw all risks on the contractor, and forced the contractor to do very careful planning before submitting a proposal.

In some areas, pre-characterisation may not be possible because of inaccessibility or high radiation dose levels. These should be clearly identified in the scope of work, and a separate contract rider (or addendum) issued to deal with these areas.

Experience has shown that scope changes are necessary either through an unidentified change in facility conditions or through a management change in direction or objectives. These need to be immediately recorded in contract documents and adjustments made in budgets and schedules.

Change control procedures

The owner/licensee needs to establish a policy of change control and prepare the detailed procedures for implementing scope changes into the contract(s), budget and schedule. Part of any EVMS training programme should be a session on change control and use of procedures.

In some cases, scope changes need to be implemented immediately for safety or security reasons and there may not be sufficient time to prepare all the documentation and negotiate the revised budget and schedule. In these situations, the project manager may authorise the contractor to perform the work under an interim adjustment in budget and schedule, with a limit on expenditure subject to final scope change modifications. This happens frequently in the field, and these "horse trading" situations often are accomplished effectively and co-operatively. Subsequent follow-up with the formal documentation and budget/schedule changes should not be delayed.

8. Cost Performance Reports

The EVMS programme is only effective if the information on project status is communicated to the programme manager early so adjustments and course re-direction can be made in a timely manner. This is formally accomplished in the cost performance report issued (typically) monthly by the management staff. Each company (owner/licensee and contractor) will develop its own report format to suit its needs. As a guide, the US DOE has published five report formats (Humphreys, 1984) which are used by its major contractors on projects. The reader is encouraged to use the following link to obtain a clearer copy of these forms: www.directives.doe.gov/directives/0413.3-EGuide-10a/view (US DOE, 2012). These are described herein.

The cost performance report (CPR) is the most comprehensive of the EVMS reports. It is normally a monthly report and has five different formats:

- Format 1 – Work breakdown structure (WBS);
- Format 2 – Organisational breakdown structure (OBS);
- Format 3 – Baseline;
- Format 4 – Staffing (manpower);
- Format 5 – Variance analysis report (with explanation and problem analysis).

Appendix B shows the five US DOE report formats. Very large projects use all five formats, prepared and issued by contractors (or the owner/licensee), to determine the detailed status of the programme. Depending on the size and duration of a programme, the owner/licensee may not require all the reports and may delete one or more of them. As a minimum to reduce paperwork, only the CPR Format 1 (WBS) and Format 5 (variance analysis report) may be required.

As noted earlier, most accounting software packages will perform the earned value calculations every two weeks as part of the payroll calculations. While these accounting reports are not reported every two weeks, it provides the programme manager an early indication of potential problems arising.

9. EVMS Assessment

The EVMS programme has been used extensively on all United States government programmes, including the DOE, the Department of Defense, US Navy, the National Aeronautics and Space Administration (NASA) and all major contractors performing services for these organisations. Internationally, the British Aerospace Military Aircraft Division, ALSTOM Transport Ltd., Cofap Automotive Suspension (C.A.S.) R&D Division (an Italian automotive equipment supplier), and many others have adopted the EVMS for control of multi-million and multi-billion dollar (or euro) projects. There are numerous professional training organisations offering courses on EVMS principles and practices, with professional credit offered to support licensure (chartered) requirements.

While seemingly overwhelming at first, the EVMS organisation and logic are straightforward. It requires a management commitment and culture change to implement the programme. Comprehensive training is necessary, and should involve all levels of management and prospective contractors. Start with a small project, and learn with minimum risk. Then graduate to larger projects. The investment is small relative to the alternative of continued cost and schedule over-runs, and management frustration and embarrassment. Success will build stakeholder confidence and trust.

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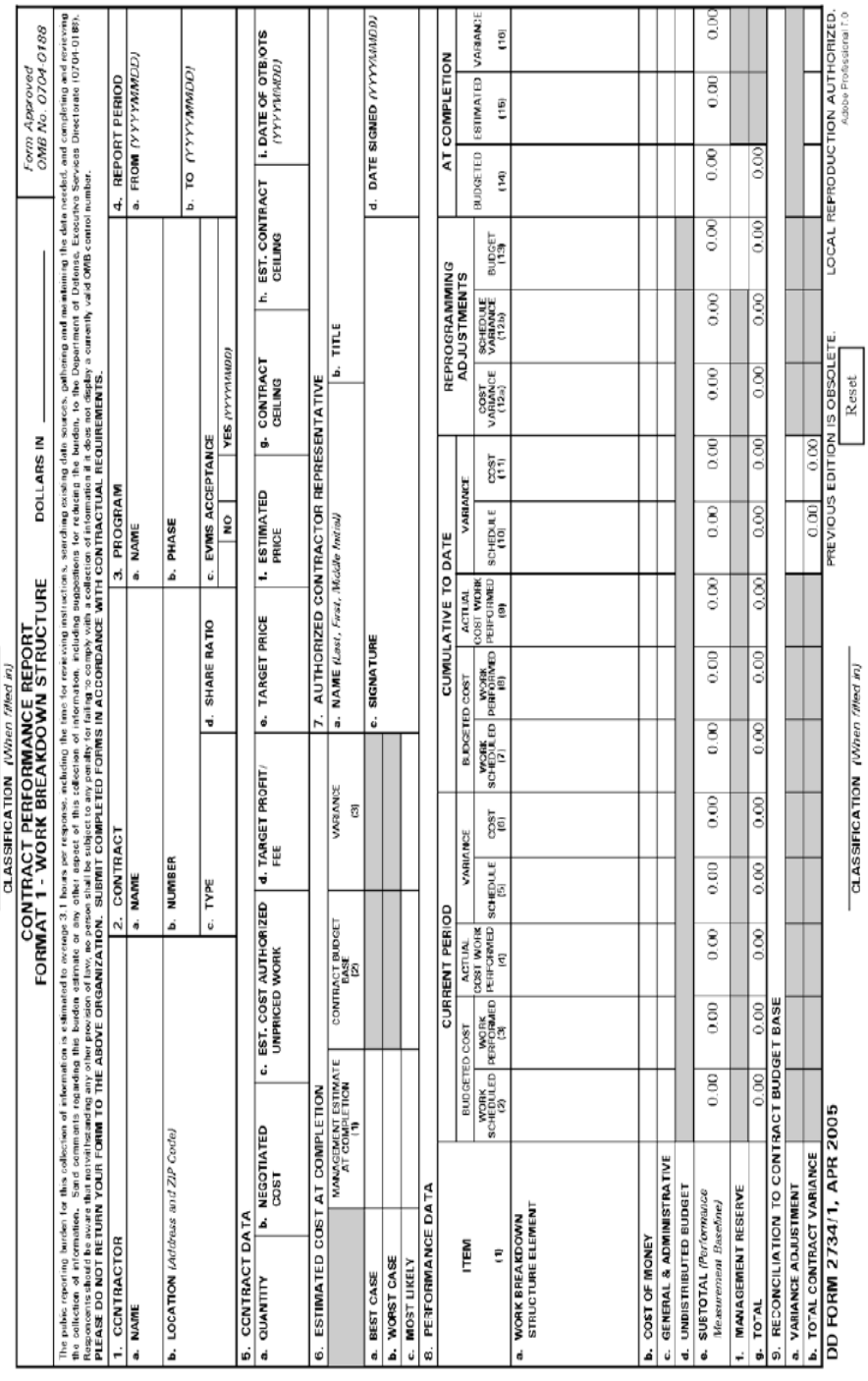
Appendix A: List of Acronyms

AC	Actual cost
ACWP	Actual cost of work performed
BAC	Budget at completion
BCWP	Budgeted cost for work performed
BCWS	Budgeted cost for work scheduled
BR	Budget remaining
CA	Control account
CBB	Contract budget base
CP	Critical path
CPI	Cost performance index
Cum	Cumulative
CSCS	Cost and schedule control system
CV	Cost variance
EAC	Estimate at completion
ETC	Estimate to complete
EV	Earned value
EVMS	Earned value management system
LOE	Level of effort
LRE	Latest revised estimate (at completion)
M	Million
MR	Management reserve
OBS	Organisational breakdown structure
PB	Performance baseline
PEP	Project execution plan
PMB	Performance measurement baseline
PP	Planning package
PV	Planned value
RAM	Responsibility assignment matrix
SPI	Schedule performance index
SV	Schedule variance
TCPI	To complete performance index

TF	Total float
TPC	Total project cost
UB	Undistributed budget
VAC	Variance at completion
WBS	Work breakdown structure
WP	Work package
WR	Work remaining

Appendix B: US DOE Report Formats

Format 1: Work breakdown structure



CLASSIFICATION *(When filled in)*

CONTRACT PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE
DOLLARS IN _____

Form Approved OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 31 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION. SUBMIT COMPLETED FORMS IN ACCORDANCE WITH CONTRACTUAL REQUIREMENTS.

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME	a. NAME	a. NAME	a. FROM *(YYYYMMDD)*
b. LOCATION *(Address and ZIP Code)*	b. NUMBER	b. PHASE	b. TO *(YYYYMMDD)*
	c. TYPE / d. SHARE RATIO	c. EVMS ACCEPTANCE (NO / YES *(YYYYMMDD)*)	

5. CONTRACT DATA								
a. QUANTITY	b. NEGOTIATED COST	c. EST. COST AUTHORIZED UNPRICED WORK	d. TARGET PROFIT/ FEE	e. TARGET PRICE	f. ESTIMATED PRICE	g. CONTRACT CEILING	h. EST. CONTRACT CEILING	i. DATE OF OTB/OTS *(YYYYMMDD)*

6. ESTIMATED COST AT COMPLETION				7. AUTHORIZED CONTRACTOR REPRESENTATIVE	
	MANAGEMENT ESTIMATE AT COMPLETION (1)	CONTRACT BUDGET BASE (2)	VARIANCE (3)	a. NAME *(Last, First, Middle Initial)*	b. TITLE
a. BEST CASE				c. SIGNATURE	d. DATE SIGNED *(YYYYMMDD)*
b. WORST CASE					
c. MOST LIKELY					

8. PERFORMANCE DATA

ITEM	CURRENT PERIOD				CUMULATIVE TO DATE				VARIANCE		REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
	BUDGETED COST		ACTUAL COST OF WORK PERFORMED (4)	VARIANCE	BUDGETED COST		ACTUAL COST OF WORK PERFORMED (9)	VARIANCE			COST VARIANCE (12a)	SCHEDULE VARIANCE (12b)	BUDGET (13)	ESTIMATED	VARIANCE
(a)	WORK SCHEDULED (2)	WORK PERFORMED (3)		SCHEDULE (5)	COST (6)	WORK SCHEDULED (7)	WORK PERFORMED (8)		SCHEDULE (10)	COST (11)				BUDGETED (14)	ESTIMATED (15)	(16)
a. WORK BREAKDOWN STRUCTURE ELEMENT															
b. COST OF MONEY															
c. GENERAL & ADMINISTRATIVE															
d. UNDISTRIBUTED BUDGET															
e. SUBTOTAL *(Performance Measurement Baseline)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
f. MANAGEMENT RESERVE															
g. TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
9. RECONCILIATION TO CONTRACT BUDGET BASE															
a. VARIANCE ADJUSTMENT															
b. TOTAL CONTRACT VARIANCE									0.00	0.00					

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Format 2: Organisational categories

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CONTRACT PERFORMANCE REPORT
FORMAT 2 - ORGANIZATIONAL CATEGORIES DOLLARS IN _____

Form Approved OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average .8 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION. SUBMIT COMPLETED FORMS IN ACCORDANCE WITH CONTRACTUAL REQUIREMENTS.**

1. CONTRACTOR	2. CONTRACT		3. PROGRAM	4. REPORT PERIOD
a. NAME	a. NAME		a. NAME	a. FROM *(YYYYMMDD)*
b. LOCATION *(Address and ZIP Code)*	b. NUMBER		b. PHASE	b. TO *(YYYYMMDD)*
	c. TYPE	d. SHARE RATIO	c. EVMS ACCEPTANCE NO ☐ YES ☐ *(YYYYMMDD)*	

5. PERFORMANCE DATA

ITEM (1)	CURRENT PERIOD: BUDGETED COST WORK SCHEDULED (2)	CURRENT PERIOD: BUDGETED COST WORK PERFORMED (3)	CURRENT PERIOD: ACTUAL COST WORK PERFORMED (4)	CURRENT PERIOD: VARIANCE SCHEDULE (5)	CURRENT PERIOD: VARIANCE COST (6)	CUMULATIVE TO DATE: BUDGETED COST WORK SCHEDULED (7)	CUMULATIVE TO DATE: BUDGETED COST WORK PERFORMED (8)	CUMULATIVE TO DATE: ACTUAL COST WORK PERFORMED (9)	CUMULATIVE TO DATE: VARIANCE SCHEDULE (10)	CUMULATIVE TO DATE: VARIANCE COST (11)	REPROGRAMMING ADJUSTMENTS: COST VARIANCE (12a)	REPROGRAMMING ADJUSTMENTS: SCHEDULE VARIANCE (12b)	REPROGRAMMING ADJUSTMENTS: BUDGET (13)	AT COMPLETION: BUDGETED (14)	AT COMPLETION: ESTIMATED (15)	AT COMPLETION: VARIANCE (16)
a. ORGANIZATIONAL CATEGORY				0.00												
b. COST OF MONEY																
c. GENERAL & ADMINISTRATIVE																
d. UNDISTRIBUTED BUDGET																
e. SUBTOTAL *(Performance Measurement Baseline)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
f. MANAGEMENT RESERVE																
g. TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

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Format 3: Baseline

CLASSIFICATION *(When filled in)*

CONTRACT PERFORMANCE REPORT
FORMAT 3 - BASELINE DOLLARS IN _____

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OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 6.3 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION. SUBMIT COMPLETED FORMS IN ACCORDANCE WITH CONTRACTUAL REQUIREMENTS.

1. CONTRACTOR	2. CONTRACT		3. PROGRAM	4. REPORT PERIOD
a. NAME	a. NAME		a. NAME	a. FROM *(YYYYMMDD)*
b. LOCATION *(Address and ZIP Code)*	b. NUMBER		b. PHASE	b. TO *(YYYYMMDD)*
	c. TYPE	d. SHARE RATIO	c. EVMS ACCEPTANCE ☐ NO ☐ YES *(YYYYMMDD)*	

5. CONTRACT DATA						
a. ORIGINAL NEGOTIATED COST	b. NEGOTIATED CONTRACT CHANGES	c. CURRENT NEGOTIATED COST *(a. + b.)*	d. ESTIMATED COST OF AUTHORIZED UNPRICED WORK	e. CONTRACT BUDGET BASE (c. + d.)	f. TOTAL ALLOCATED BUDGET	g. DIFFERENCE *(e. - f.)*
		0.00		0.00		0.00

h. CONTRACT START DATE *(YYYYMMDD)*	i. CONTRACT DEFINITIZATION DATE *(YYYYMMDD)*	j. PLANNED COMPLETION DATE *(YYYYMMDD)*	k. CONTRACT COMPLETION DATE *(YYYYMMDD)*	l. ESTIMATED COMPLETION DATE *(YYYYMMDD)*

6. PERFORMANCE DATA

ITEM	BCWS CUMULATIVE TO DATE	BCWS FOR REPORT PERIOD	BUDGETED COST FOR WORK SCHEDULED (BCWS) *(Non-Cumulative)*											UNDISTRIBUTED BUDGET	TOTAL BUDGET
			SIX MONTH FORECAST *(Enter names of months)*						ENTER SPECIFIED PERIODS						
			+1	+2	+3	+4	+5	+6							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
a. PERFORMANCE MEASUREMENT BASELINE *(Beginning of Period)*															0.00
b. BASELINE CHANGES AUTHORIZED DURING REPORT PERIOD															
c. PERFORMANCE MEASUREMENT BASELINE *(End of Period)*															0.00
7. MANAGEMENT RESERVE															
8. TOTAL															0.00

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Format 4: Staffing

CLASSIFICATION *(When filled in)*

CONTRACT PERFORMANCE REPORT
FORMAT 4 - STAFFING

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The public reporting burden for this collection of information is estimated to average 5.0 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION. SUBMIT COMPLETED FORMS IN ACCORDANCE WITH CONTRACTUAL REQUIREMENTS.

1. CONTRACTOR	2. CONTRACT		3. PROGRAM	4. REPORT PERIOD
a. NAME	a. NAME		a. NAME	a. FROM *(YYYYMMDD)*
b. LOCATION *(Address and ZIP Code)*	b. NUMBER		b. PHASE	b. TO *(YYYYMMDD)*
	c. TYPE	d. SHARE RATIO	c. EVMS ACCEPTANCE NO ☐ YES ☐ *(YYYYMMDD)*	

5. PERFORMANCE DATA *(All figures in whole numbers)*

ORGANIZATIONAL CATEGORY	ACTUAL CURRENT PERIOD	ACTUAL END OF CURRENT PERIOD *(Cumulative)*	FORECAST *(Non-Cumulative)* SIX MONTH FORECAST BY MONTH *(Enter names of months)*						ENTER SPECIFIED PERIODS					AT COMPLETION
			+1	+2	+3	+4	+5	+6						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
6. TOTAL DIRECT	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Format 5: Variance analysis

CLASSIFICATION *(When filled in)*

CONTRACT PERFORMANCE REPORT
FORMAT 5 - EXPLANATIONS AND PROBLEM ANALYSES

Form Approved
OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 36.0 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to the Department of Defense, Executive Services Directorate (0704-0188). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION. SUBMIT COMPLETED FORMS IN ACCORDANCE WITH CONTRACTUAL REQUIREMENTS.**

1. CONTRACTOR	2. CONTRACT		3. PROGRAM	4. REPORT PERIOD
a. NAME	a. NAME		a. NAME	a. FROM *(YYYYMMDD)*
b. LOCATION *(Address and ZIP Code)*	b. NUMBER		b. PHASE	b. TO *(YYYYMMDD)*
	c. TYPE	d. SHARE RATIO	c. EVMS ACCEPTANCE ☐ NO ☐ YES *(YYYYMMDD)*	

5. EVALUATION

Discussion should include but is not limited to:

Summary Analysis:

- Summary of Overall Contract Variances
- Differences between EAC's (Blocks 6.a., 6.b., 6.c., or Block 8.15)
- Changes in Undistributed Budget
- Changes in Management Reserve
- Significant timephasing shifts in Baseline (BCWS) (Format 3)
- Significant timephasing shifts or overall changes in Forecasted Staffing (Format 4)
- Discussion of Over Target Baseline and/or Over Target Schedule incorporation

Analysis of Significant Variances (identify and describe each):

- Type and Magnitude of Variance
- Explanation of Significant Reasons
- Effect on Immediate Task
- Effect on Total Contract
- Corrective Actions Taken or Planned

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Appendix C: Earned Value Management System (EVMS) Training Sessions

Prepared by T.S. LaGuardia, PE, CEE for the OECD/NEA

Session I – Introduction to EVMS

Scope of Session I

The objective of Session I is to introduce the Earned Value Management System (EVMS) and lay the groundwork for the succeeding sessions. The following topics will be discussed:

- the definition of earned value management;
- the differences between traditional management and earned value management;
- how earned value management fits into a programme and project environment;
- the framework necessary for proper earned value implementation.

What is earned management?

EVMS is an integrated set of policies, procedures and practices to support programme and project management as a decision-enhancing tool and a critical component of risk management. The following are characteristics of EVMS:

- effectively integrating a project's work scope, cost and schedule into a single performance measurement baseline (PMB);
- reliably tracks:
  - planned value (PV) of work to be performed or the budgeted cost for work scheduled (BCWS);
  - earned value (EV) of actual work performed or the budgeted cost for work performed (BCWP);
  - actual cost (AC) of work performed (ACWP);
- provides performance measures against the PMB;
- provides means of identifying, reviewing, approving and incorporating changes to the PMB;
- provides trend analysis and evaluation of estimated cost at completion;
- provides a sound basis for problem identification, corrective actions and management re-planning.

Why use EVMS?

Earned value permits management to determine:

- Where have we been?
- Where are we now?
- Where are we going?

It provides a quantitative measurement of the status of a project, and alerts of potential problems that need to be corrected during each reporting period. It further provides a mechanism to look ahead and to anticipate problems before they occur.

Guidance for EVMS

EVMS follows the internationally accepted guidance contained in the American National Standard Institute (ANSI) document, *Earned Value Management System* (ANSI/EIA-748-B, 10 September 2007). Most United States government agencies follow this standard, including the US Department of Energy (US DOE) and the US Department of Defense (US DOD). Other organisations endorsing this guide are the Association for the Advancement of Cost Engineering (AACEI) and the Project Management Institute (PMI).

Where does EVMS fit into the overall programme?

First of all, the notions of "project" and "programme" must be clearly defined. A project is a group of activities or tasks to perform a service or create a product. It has a defined beginning and end. A programme is a group of projects managed collectively to accomplish an overall objective by co-ordinating resources, costs and schedules within a defined funding limit. While the terms "programme" and "project" are used interchangeably at times, for our purposes the definitions above apply throughout this training session. The list below follows the steps involved in programme management, and situates EVMS within those steps:

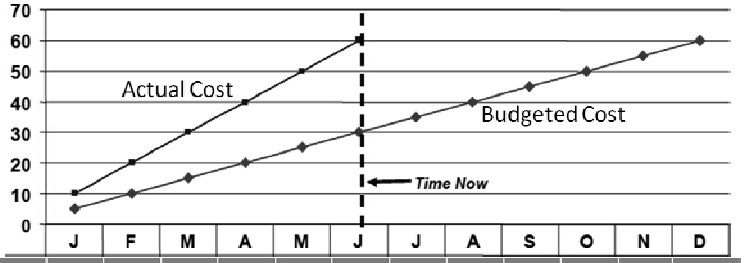
- Programme management:

– project management characterisation;
– budgeting;
– cost proposals/negotiations/contracts;
– scheduling;
– funding;
– cost/schedule collection;
– change control;
– *earned value management*;
– forecasting;
– resource management;
– reporting;
– risk management.

Comparison of traditional management to EVMS

Traditional management only has two data sources, the budget (or planned) expenditures and the actual expenditures. The comparison of budget and actual expenditures only shows what was planned to be spent versus what was actually spent at any given time. It does not show, however, the physical amount of work performed, or what was produced for the money spent, or whether what was produced was according to the schedule as originally planned. It simply does not relate the true cost performance of the project. As Figure A.1 demonstrates, this traditional comparison only represents the relationship of what was budgeted (planned) versus what was actually spent.

Figure A.1: Traditional management comparison



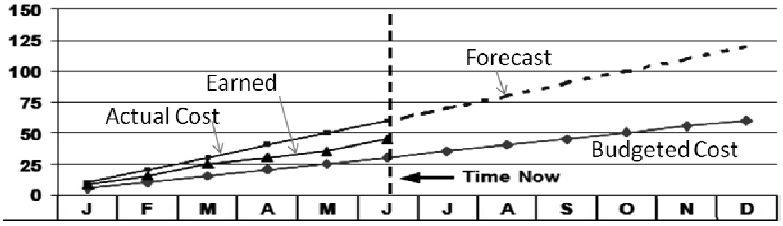
Budgeted Cost	5	10	15	20	25	30	35	40	45	50	55	60
Actual Cost	10	20	30	40	50	60						

By comparison, earned value management has three data sources:

- the budget (or planned) value of work scheduled;
- the actual value of work completed;
- the "earned value" of the physical work completed.

Earned value uses these three data sources and compares them to provide a more informative picture of the project status. Figure A.2 shows the relationship of these three data sources for a project.

Figure A.2: EVMS evaluation comparing budgeted cost, actual costs and earned value



Budgeted Cost	5	10	15	20	25	30	35	40	45	50	55	60
Actual Cost	10	20	30	40	50	60						
Earned	8	15	25	30	45							
Forecast							70	80	90	100	110	120

Figure A.2 shows the budged cost, actual costs and earned value. The budgeted cost line is below both the actual cost and the earned value lines. This indicates that the project is expending more than was budgeted. If the project follows the current spending rate, the forecasted cost will continue to exceed the budgeted cost. This, however, is not all that can be extrapolated from the graph.

Comparing the earned value line to the budgeted line, it is also apparent that the project is *producing* more than was budgeted. Comparing the actual cost to the earned value, the project is spending more than was budgeted. The cost and schedule variance will show the status of project performance.

Using the example in Figure A.2, we can calculate the cost variance, BCWP – ACWP (EV – AC), or 45 – 60 = -15, or an over-run of 15. The schedule variance can be found using BCWP – BCWS (EV – PV), or 45 – 30 = 15, or ahead of schedule.

The EVMS not only shows the budgeted and actual costs, but also what was accomplished for the money spent, what the project will cost at completion and how long it will take to complete.

Framework for EVMS

EVMS relies upon inputs from the programme to establish the structure of earned value. The inputs consist of:

- work breakdown structure (WBS);
- organisational breakdown structure (OBS);
- baseline cost estimate;
- baseline schedule;
- performance measurement baseline;
- cost/resource control plan;
- change control plan.

EVMS uses simple formulae to determine the status of a programme/project. These earned value formulae are as follows:

PV	= planned value	= BCWS	= budgeted cost for work scheduled
			= what was planned to be done
EV	= earned value	= BCWP	= budgeted cost of work performed
			= what was done at budget rates
AC	= actual cost	= ACWP	= actual cost of work performed
			= what was paid for the work
BAC	= PV_{cum}	= $BCWS_{cum}$	= budget at completion
			= original budget plus changes

EVMS also incorporates outputs in the form of periodic (bi-weekly/monthly) reports to keep management informed of the status. This is done using the following variance formulae:

CV = EV – AC = BCWP – ACWP = cost variance

SV = EV – PV = BCWP – BCWS = schedule variance

CV% = (EV – AC)/EV = (BCWP – ACWP)/BCWP = cost variance, %

SV% = (EV – PV)/PV = (BCWP – BCWS)/BCWS = schedule variance, %

VAC = BAC – EAC = variance at completion

The main outputs are reports. They are the key method management uses to learn the status of a programme. There are several suggested formats used. The US DOE formats listed here are provided in Appendix A:

- *Format 1 – Work breakdown structure*. Provides cost and schedule performance data by WBS element.
- *Format 2 – Organisational breakdown structure*. Provides Format 1 data for the contractor's organisation.
- *Format 3 – Baseline*. Provides the budget baseline plan against which performance is measured.
- *Format 4 – Staffing*. Provides staffing forecasts for correlation with the budget plan and cost estimates.
- *Format 5 – Variance analysis (explanation and problem analyses)*. A narrative report used to explain significant cost and schedule variances and other identified contract problems and topics to the control account level.

Summary

This session provided a detailed definition of the EVMS. The benefits of EVMS over traditional cost and schedule approaches were compared, and a framework for EVMS was provided based on the WBS, baseline cost and schedule and performance metrics. It was explained how variances are used to determine the status of a project, and several reporting formats were provided as examples.

Training Session II – Work breakdown, organisational structures and responsibility assignment

Scope of Session II

The objective of this session is to review the process of setting up a work breakdown structure, an organisational structure and a responsibility assignment matrix for a programme (project). This session will include examples of the foregoing three elements for typical decommissioning scenarios.

Work breakdown structure (WBS)

A WBS is a way of organising a project into groups of activities or tasks that are inter-related to achieve a specified scope of work and objective. The WBS is used to develop the project baseline cost estimate and schedule, and to establish controls to ensure objectives will be met. Like cost estimates and schedules, the WBS is a living, changing tool that reflects project changes as they occur. Pictorially, the WBS is drawn to look like a company organisation chart, but functions in an entirely different way. Figure A.3 shows a portion of a WBS for a decommissioning project. The strata are identified as Levels (1, 2, 3, etc.) to show the inter-relationships involved.

Figure A.3: Pictorial WBS

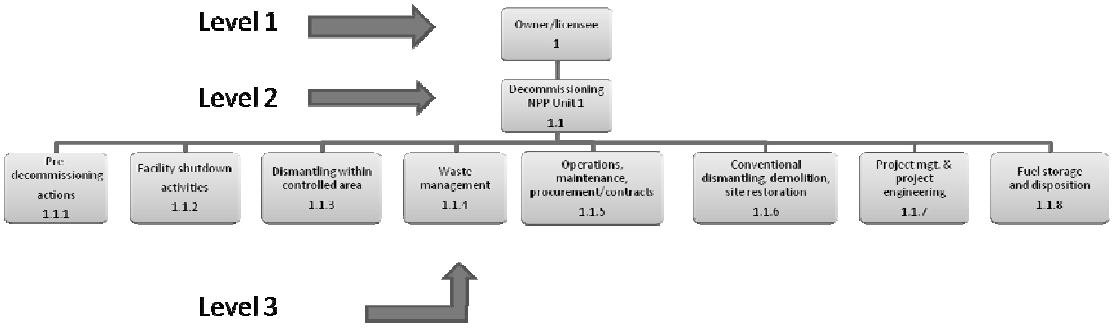
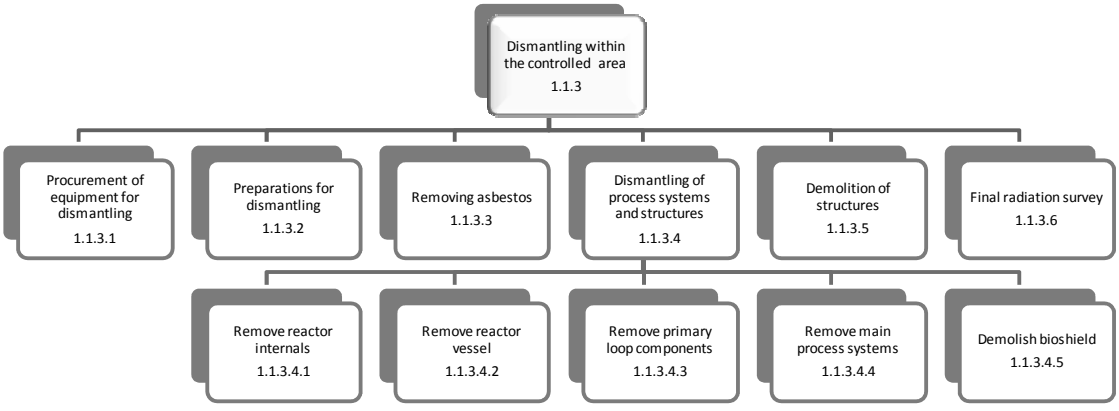


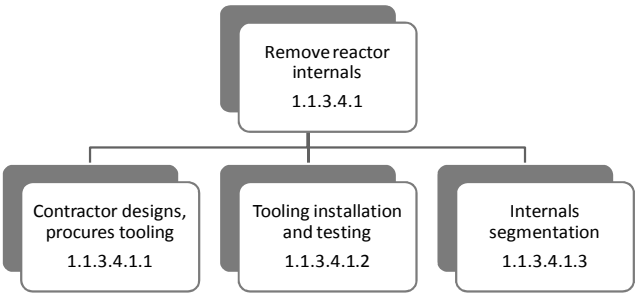
Figure A.4 breaks down the activities below the "Level 3" indicated in Figure A.3. Using "Dismantling of main process systems and structures" as an example, further breakdowns would be identified. Level 5 could, for example, be identified as a control account (discussed below). Level 6 and below would be repeated in the same manner.

Figure A.4: Breakdown of activities below Level 3 in Figure A.3



The process would be continued down to the level that specific contractor work could be identified. For example, "Remove reactor vessel internals 1.1.3.4.1" would be further broken down to the contractors designing and procuring the tooling, installation and testing, and finally segmenting the internals. This is shown in Figure A.5.

Figure A.5. Further breakdown of the WBS



The graphical hierarchal diagrams shown in Figures A.3 through A.5 is much too cumbersome to use in practice. Instead, an alpha-numeric listing would be used as follows:

1 Owner /licensee

1.1 Decommissioning NPP Unit 1

1.1.1 Pre-decommissioning actions

1.1.2 Facility shutdown actions

1.1.3 Dismantling within controlled area

1.1.4 Waste management

1.1.5 Operations, maintenance, procurement/contracts

1.1.6 Conventional dismantling, demolition, site restoration

1.1.7 Project management and project engineering

1.1.8 Fuel storage and disposition

WBS dictionary

When the WBS is developed down to the management level desired, the next step is to prepare the WBS dictionary. The WBS dictionary is a written description of the scope of each WBS element. It defines what will be accomplished and what outputs (deliverables) will be produced. The dictionary will ultimately describe the statements of work (SOW) for the project, from which subcontracts can be prepared. This step is critical to properly understanding the work and planning each activity, to avoid confusion and minimise change orders to the contracts.

Organisational breakdown structure (OBS)

A similar hierarchal breakdown structure would be created for the organisations responsible for performing the activities identified in the WBS. The organisational breakdown structure (OBS) would contain the specific organisation(s) responsible for each activity. It also identifies the technologies, equipment, interfaces and limitations for each organisation. Figure A.6, for example, considers the contractor's work for the "Remove vessel internals" project shown in Figure A.5.

The owner/licensee (O/L) will have responsibilities to oversee the contractor and provide support services. The O/L must provide radiation protection, health physics services, operation of cranes, electrical power, HEPA ventilation, lighting, protective clothing, case transportation, disposal services, engineering oversight and security (Figure A.7). These may be summarised into the categories "Health & safety", "Operation & maintenance", "Waste management", "Project engineering" and "Security".

Responsibility assignment matrix (RAM)

The RAM shows the WBS and OBS, and the integration of the specific responsibilities of each organisation for each specific task. Normally these are shown at the lowest level, but are shown at a summary

level for our purposes (Figure A.8). This is the point at which the project manager assigns control accounts for the work packages.

Working from the budgeted estimates of cost (or duration hours in a fixed-price contract), an example of a contractor's RAM is shown in Figure A.9. The cost values are fictitious, but representative of the distribution of the budget.

Figure A.6: OBS for "Removing vessel internals" project shown in Figure A.5

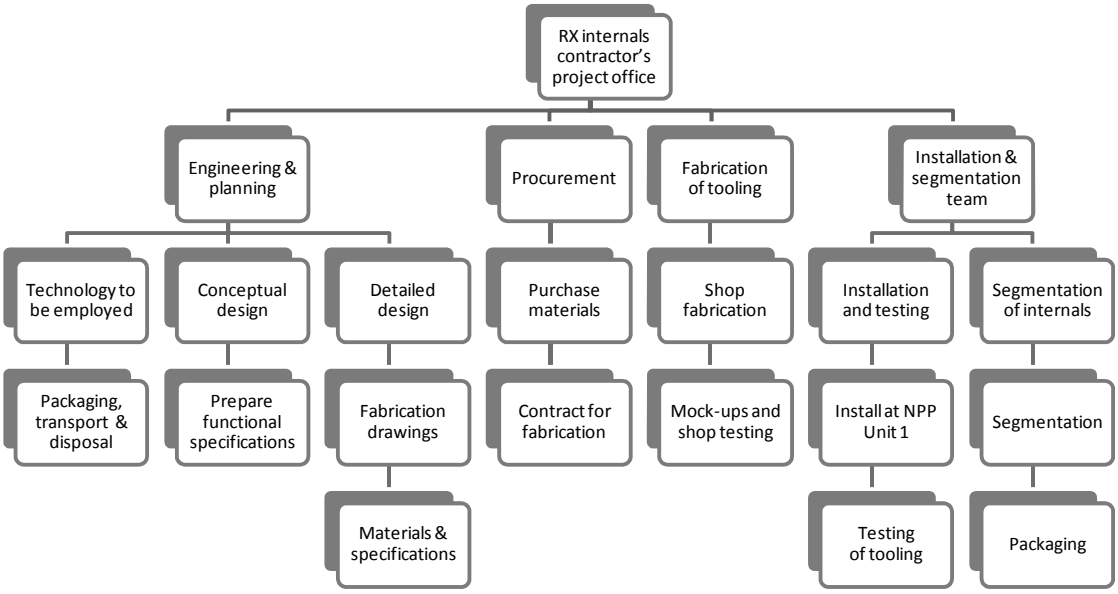
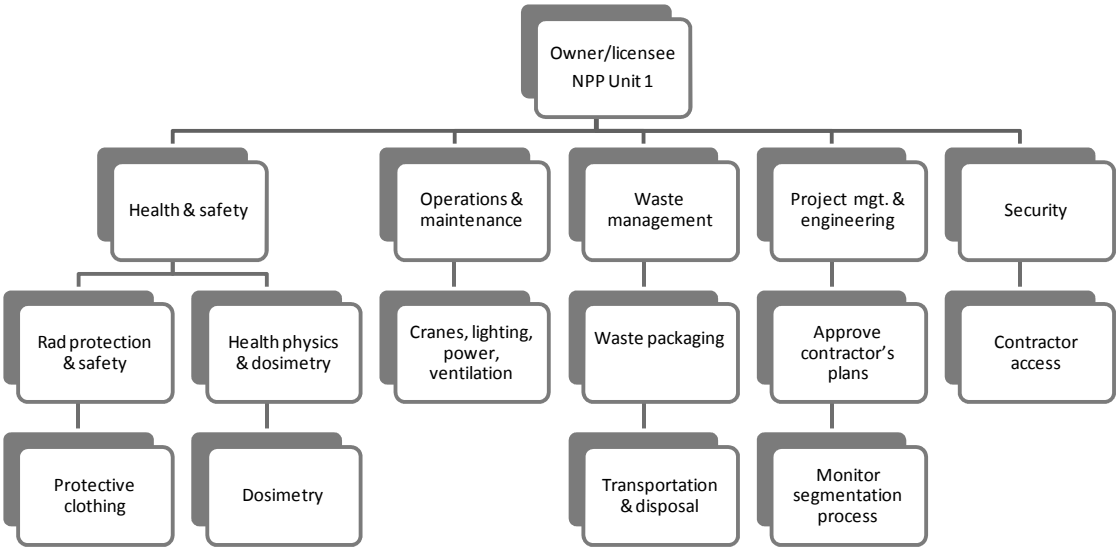


Figure A.7: OBS of owner/licensee responsibilities



The example in Figure A.9 shows how to set up the RAM for one part of the decommissioning process, but illustrates the structure of the relationships. In practice, the process is much simpler as the baseline cost estimate and the schedule baseline estimate provide the cost and duration data for each WBS element. The OBS cross-walk to the RAM is a straightforward process. As noted earlier, the WBS in the alpha-numeric format makes preparation of the RAM much easier. The international structure for decommissioning costs

(ISDC) provides the framework for the WBS. This is one of the advantages of the standardisation of costs and schedules.

Figure A.8: Responsibility assignment matrix (RAM)

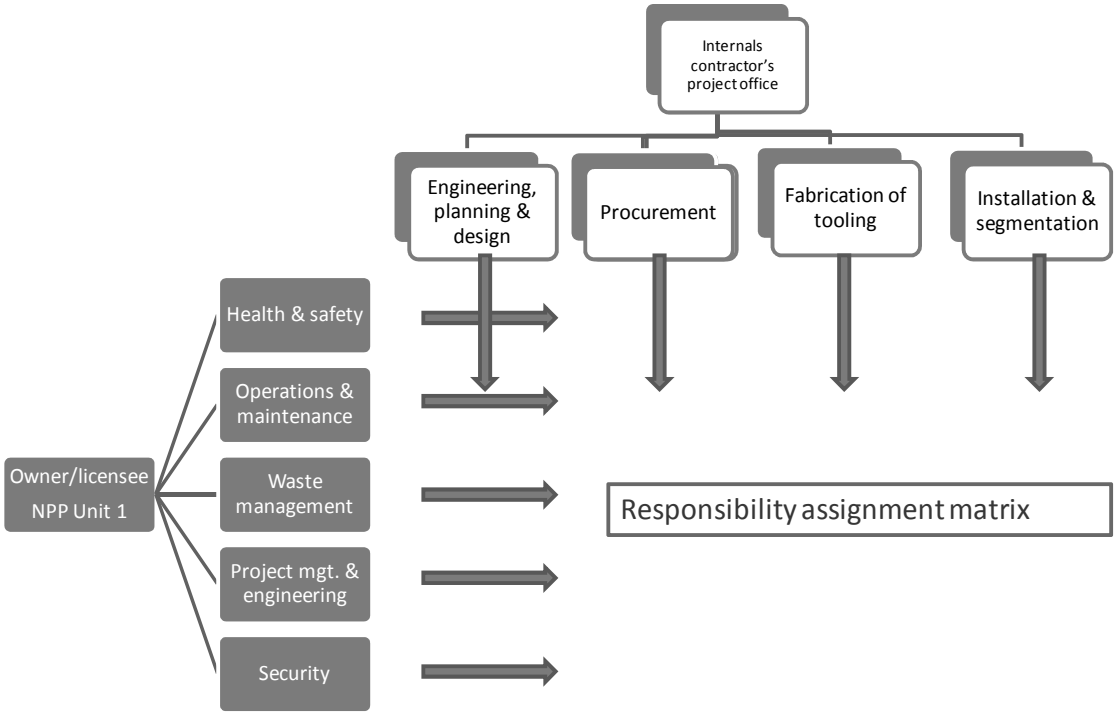


Figure A.9: Contractor's RAM

Performing dept.	Manager	Engineering & planning			Procurement	Fabrication	Install & segment	
		Technology	Conceptual design	Detailed design	Purchase mat'ls & contract for fabrication	Fabricate & shop test	Install & test at NPP-1	Segment & package
Engineering dept.	Mr. I. Bergman	300 hrs/ EUR 45 k	450 hrs/ EUR 67.5 k	2 800 hrs/ EUR 280 k				
Purchasing	Mrs. E. Piaf				250 hrs/ EUR 25 k + EUR 500 k mat'ls			
Shop	Mr. A. Segovia					19 200 hrs/ EUR 1 920 k		
Field team	Mr. M. Mastroianni						7 200 hrs/ EUR 1 080 k	10 400 hrs/ EUR 1 560 k

Summary

Session II described the elements of the WBS, OBS and RAM, and showed examples of how to set them up. The WBS dictionary is an important part of this process, as it identifies the scope of work for each task. This scope definition is used to prepare the statement of work (SOW) for contracts. The RAM is also important, as it defines the limits of responsibility for each group within an organisation.

Often there is a tendency to skip these steps in the interest of "getting started on a project and seeing some progress", but the end result is a poorly planned job with many opportunities for contractor change orders. This can only lead to cost and schedule over-runs, and potentially to litigation. *Failing to plan is planning to fail!*

Training Session III – Budget, schedule and control accounts

Scope of Session III

The objective of this session is to review the process of developing a schedule and cost budget, and assigning control accounts for the earned value management. This session includes the following topics:

- schedule estimate development;
- cost estimate development;
- control accounts, work packages and planning packages.

Schedule estimate development

The initial planning for a decommissioning project involves:

- Statement of work – what will be done?
- WBS – how the work will be structured and tracked.
- OBS – assigning responsibility for the work.
- Scheduling – organising the activities into a logical sequence to reflect all objectives, interactions and constraints.

Schedule baseline

The process of developing a schedule and cost baseline is an interactive one. The schedule affects the costs, and the costs affect the schedule. The first step is to identify the scope of the project. The major activities that must be performed to accomplish the objective (scope) must then be identified.

It is often helpful to lay out a network diagram of activities to see what has to be done and the inter-relationships between them. This is done with "pencil and paper", as there will be many changes as the project is constructed. The key product is to see the prerequisites to accomplishing a task, and then the predecessor and successor activities to each step.

There will be multiple paths necessary to achieve the end product of an activity, and these need to be reconciled as the network is drawn. The critical path activities will begin to be evident as the network shows the multiple interactions involved.

The most effective process is to gather the subject matter experts (SME) of the company in a room and have them call out the tasks that need to be included (Figure A.10). The results can be captured on a computer using Primavera's P6 computer code, or Microsoft's Project code in the form of a Gantt chart or network diagram. The preliminary schedule forms the basis of the overall project duration before actual activity durations are included.

Using contractor input on durations of activities, determine start and end dates for each activity. A time-phased schedule should be laid out, which includes any parallel activities necessary to accomplish the task. Predecessor and successor activities on the network or Gantt chart should be identified, and an integrated schedule should be prepared on the Gantt chart as well (Figure A.11).

Sometimes a single scheduling factor determines the overall schedule for an activity. For example, the turnaround time for a shielded cask (there are a limited number of them available) can set the duration for all related activities of vessel internals removal. It takes about one week to bring a cask into the reactor building, load a segment canister under water into the case, drain and dry the cask, survey it, ship it to a disposal facility, unload it and ship the cask back to the reactor. This sequence sets the rate at which segments can be cut and loaded in canisters. If there is sufficient room in the storage pool for several canisters, the segmentation can proceed faster to complete segmentation early, but removal of the filled canisters is limited by the cask schedule. The SME should be tasked to consider these factors.

Figure A.10: Remove RX vessel internals

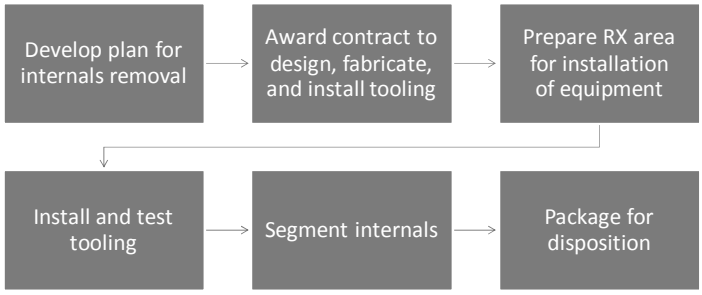


Figure A.11: Gantt chart with an integrated schedule

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Develop plan												
Award contract												
Prepare RX area												
Install and test equipment												
Segment internals												
Package for disposition												

Cost estimate development

Cost estimates for decommissioning have come a long way since the advent of the PC. The ability to handle large projects in an organised and standardised way has greatly improved estimate quality and accuracy. The Association for the Advancement of Cost Engineering International (AACEI) has established cost estimate classifications of accuracy based on the level of information available to the estimator, and the estimating methodology used (AACEI, *Cost Estimate Classification System*, Recommended Practice 18R-97) (Figure A.12).

It is beyond the scope of this session to discuss the various cost-estimating methodologies and applications. It will be assumed that a qualified method has been used that provides the level of detail needed for implementation of the EVMS. As mentioned earlier, one such standardised approach is the international structure for decommissioning costs (ISDC). ISDS uses a standard WBS format and content which ensures all aspects of a decommissioning project will be included.

Using the output of the cost estimate computer runs, the scope, duration of each activity in the schedule, and cost can be shown on the previously developed schedule. Off-the-shelf computer programs like Primavera's P6 and Microsoft's Project are set up to include the costs with the schedule and to provide an integrated cost and schedule baseline (Figure A.13).

Figure A.12: AACEI Recommended Practice 18R-97

	Primary characteristic	Secondary characteristic			
ESTIMATE CLASS	LEVEL OF PROJECT DEFINITION Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical variation in low and high ranges [a]	PREPARATION EFFORT Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgement or analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, authorisation or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to 30%	3 to 10
Class 2	30% to 70%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%	5 to 100

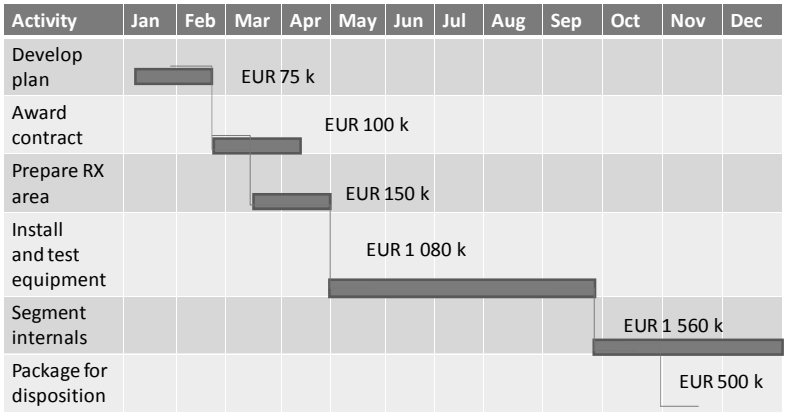
Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The ± value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

WBS reporting levels

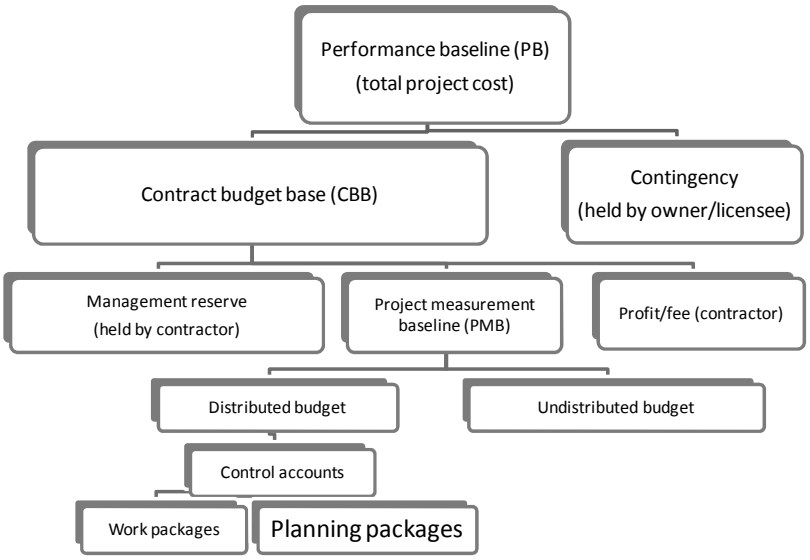
The WBS is the foundation of the EVMS performance evaluation. The performance measurement baseline is the level where earned value is determined from the sum of distributed and undistributed budgets. The distributed budget is the sum of all control accounts (sometimes called "cost account"). Control accounts report the performance of the work packages and planning packages. A diagram of levels is shown in Figure A.14.

Figure A.13: An integrated cost and schedule baseline



* Costs shown are fictitious.

Figure A.14: WBS reporting levels



Control accounts

A control account is selected by the project manager to determine earned value using:

- cost/schedule summarisation;
- variance analysis and reporting;
- responsibility assignment;
- scope description;
- corrective action planning.

The control manager is responsible for implementing the scope of work and reporting the associated performance.

Work packages (WP) identify a discrete set of tasks below the control account level. Work packages contain:

- a description or brief work statement;
- starting and ending dates;
- completion milestones;
- work-in-process measure;
- time-phased budget expressed in direct labour (hours and/or budget), material, other direct costs and subcontract budget.

The duration of a work package should be a relatively short span of time (normally, but not limited to, six months or less).

Planning packages are for future tasks within a control account that are not yet broken down into detailed work packages. A planning package has a firm budget, estimated start and complete dates and statement of work. As work becomes more clearly defined, planning packages are converted into work packages, with the following constraints. These constraints ensure the initial budget is used appropriately:

- All planning packages are converted into work packages as requirements are defined, and at a minimum, are scheduled to start at least one month beyond the current reporting period.
- Conversion of planning packages to work packages is reviewed by the team leader and documented on a revision request (RR).

Any conversion involving a change to the schedule or budget of the control account must be accompanied by a RR.

Contract baseline

The contract baseline is composed of eight elements, as shown below.

Within each control account, work packages and planning packages contain a budget divided into time increments (typically monthly) by elements of cost, such as direct labour, material, subcontract and other direct costs (ODS). As detailed planning evolves, the control account budget and schedule are authorised for implementation by a work authorisation document (WAD); no work shall be performed without an approved WAD.

Total contract price	= total contract cost + profit/fee
Total contract cost	= total contract cost w/o profit/fee
Contract budget base (CBB)	= total budget for all authorised work
Performance measurement baseline	= time-phased budget for contract performance measurement
Management reserve (MR)	= programme manager management reserve (held for unforeseen problems); different than contingency
Distributed budgets (DB)	= authorised budgets for WBS work assigned to control accounts
Undistributed budgets (UB)	= authorised work not yet allocated to WBS elements; should be distributed as soon as possible

Summary

This session presented the process of preparing cost and schedule baseline estimates, and the development of control accounts for work packages and planning packages. Decommissioning cost and schedule estimating has matured using computer programs to the point where reliable estimates are possible. Standardisation of the list of decommissioning activities helps to improve the transparency and accuracy. Control accounts collect the work and planning packages into the performance measurement baseline for determination of earned value.

Training Session IV – Earned value methods

Scope of Session IV

The objective of this session is to:

- review earned value performance metrics.
- explain the performance measurement baseline.
- show examples of EVMS computations – earned value and variances.
- provide methods for determining current and cumulative completion.
- describe control account and work package completion computation methods, which include:
  - fixed formula;
  - milestone weights;
  - milestone weights with per cent complete;
  - units complete;
  - per cent complete;
  - level of effort.

Review of performance metrics

The earned value formulae are as follows:

PV	= planned value	= BCWS	= budgeted cost for work scheduled
			= what was planned to be done
EV	= earned value	= BCWP	= budgeted cost of work performed
			= what was done at budget rates
AC	= actual cost	= ACWP	= actual cost of work performed
			= what was paid for the work
BAC	= PV_{cum}	= $BCWS_{cum}$	= budget at completion
			= original budget plus changes

The variance formulae are as listed below:

CV = EV – AC = BCWP – ACWP = cost variance

SV = EV – PV = BCWP – BCWS = schedule variance

CV% = (EV – AC)/EV = (BCWP – ACWP)/BCWP = cost variance, %

SV% = (EV – PV)/PV = (BCWP – BCWS)/BCWS = schedule variance, %

VAC = BAC – EAC = variance at completion

CPI = EV/AC = BCWP/ACWP = cost performance index

SPI = EV/PV = BCWP/BCWS = schedule performance index

EVMS computations

Using the PMB graph in Figure A.15 as our example, at the "Time Now":

BAC = $BCWS_{cum}$ = EUR 450 million

CV = BCWP – ACWP = EUR 220 M – EUR 300 M = EUR -80 M

SV = BCWP – BCWS = EUR 220 M – EUR 350 M = EUR -130 M

CV% = (BCWP – ACWP)/BCWP = -EUR 80/220 = -36.4%

SV% = (BCWP – BCWS)/BCWS = EUR -130/350 = -37.1%

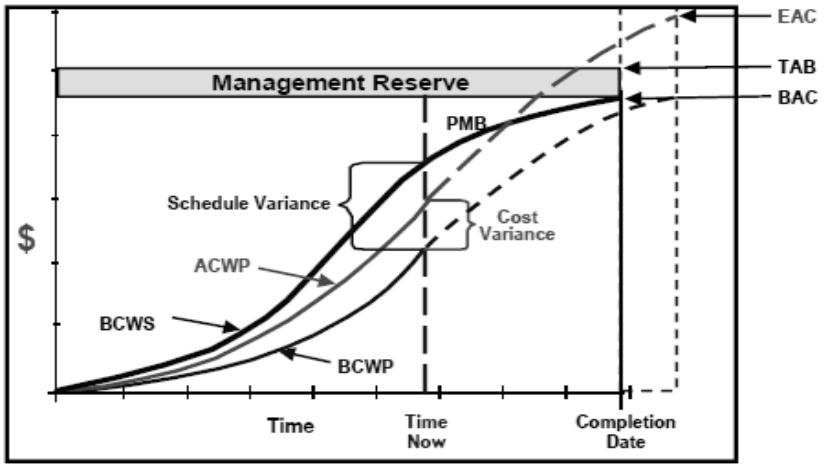
VAC = BAC – EAC = EUR 450 M – EUR 590 M = EUR -140 M

CPI = BCWP/ACWP = EUR 220 M/300 M = 0.733

SPI = BCWP/BCWS = EUR 220 M/EUR 350 M = 0.629

The results at "Time Now" indicate that this project is over budget (by EUR 80 M) and behind schedule (by EUR 130 M). The cost variance is -36.4%, and the schedule variance is -37.1%. If the project continues in the manner based on the estimate to complete, the budget at completion will be exceeded by EUR 140 M.

Figure A.15: Performance measurement baseline



Variance analyses

The programme manager will set variance thresholds at different levels, but most set the variance level between ±7 to 10%. This means that an SPI or CPI of 0.93 to 1.1 will require an official variance analysis to explain what is happening on the project. Note that it is necessary to explain positive variances as well as negative variances.

Table A.1: Summary of variances analyses

Cost Variance (CV) = EV – AC = BCWP – ACWP If the result is POSITIVE → "Under-run" If the result is NEGATIVE → "Over-run"	**Schedule Variance (SV) = EV – PV = BCWP – BCWS** If the result is POSITIVE → "On Schedule" If the result is NEGATIVE → "Behind Schedule"
Cost Variance (CV)% = CV/EV **= BCWP – ACWP/BCWP** Shows what percentage cost varies from what has been earned to date.	**Schedule Variance (SV)% = SV/PV** **= BCWP – BCWS/BCWS** Shows what percentage schedule varies from what has been planned to date.
Cost Performance Index (CPI) = EV/AC **= BCWP/ACWP** If result is less than 1.0, cost is GREATER than budgeted. If the result greater than 1.0, cost is LESS than budgeted.	**Schedule Performance Index (SPI) = EV/PV** **= BCWP/BCWS** If result is less than 1.0, project is BEHIND schedule. If the result greater than 1.0, project is AHEAD of schedule.

Estimate and budget at completion

The estimate at completion (EAC) is the actual cost to date plus an objective estimate of costs for remaining authorised work. It is sometimes called the latest revised estimate (LRE). The objective in preparing an EAC is to provide an accurate projection of cost at the completion of the project. There are multiple ways and varying degrees of detail to calculate EAC. The budget at completion (BAC) is the sum of all budgets allocated to a project scope. The project BAC must always equal the project total PV. As the discussion progresses, the shorter terms of AC, EV and PV will be used for actual cost (ACWP), earned value (BCWP) and planned value (BCWS).

The EAC is the best estimate of the total cost at the completion of the project. The EAC is a periodic evaluation of the project status by the control account manager, usually on a monthly basis or when a significant change happens to the project. The EAC is also evaluated annually for the programme. The EAC is determined for the programme, control accounts and work packages.

The following are the typical EAC formulae used:

EAC = AC + ETC

EAC = (AC/EV) × (BAC)

EAC = BAC/CPI

EAC = AC + [(BAC – EV)/CPI]

In all cases, the variance at completion [VAC = BAC – EAC] must be calculated; it will be different for each formulae used. If the VAC is positive (+), the project is under-run. If it is negative (-), it is over-run. An example is provided here, using the data from Figure A.15.

- The first formula is EAC = AC + ETC, where ETC is the estimate to complete:
  - The ETC can be read as EUR 590 M – EUR 300 M = EUR 290 M.
  - The AC = EUR 300 M.
  - Therefore, the EAC = EUR 300 M + EUR 290 M = EUR 590 M.
  - To calculate the variance at completion (VAC), the BAC was determined to be EUR 450 M.
  - VAC = BAC – EAC = EUR 450 M – EUR 590 M = EUR -140 M.
  - The budget at completion will be exceeded by EUR 140 M.
- The second formula is EAC = (AC/EV) × (BAC):
  - This formula assumes the same "spend rate" for the remainder of the project.
  - The EAC = (EUR 300 M/EUR 220 M) × EUR 450 M = 1.364 × EUR 450 M = EUR 613.6 M.
  - VAC = BAC – EAC = EUR 450 M – EUR 613.6 M = EUR -163.6 M.
  - The budget at completion will be exceeded by EUR 163.6 M.
- The third formula is EAC = BAC/CPI:
  - This formula assumes the same "spend rate" for the remainder of the project.
  - EAC = EUR 450 M/0.733 = EUR 613.9 M.
  - VAC = BAC – EAC = EUR 450 M – EUR 613.9 M = EUR -163.9 M.
  - The budget at completion will be exceeded by 163.9 M.
- The fourth formula is EAC = AC + [(BAC – EV)/CPI]:
  - EAC = EUR 300 M + [(EUR 450 M – EUR 220 M)/0.733].
  - EAC = EUR 300 M + EUR 313.8 M = EUR 613.8 M.
  - VAC = BAC – EAC = EUR 450 M – EUR 613.8 M = EUR -163.8 M.
  - The budget at completion will be exceeded by EUR 163.8 M.

As can be seen from Table A.2, the results of the first formula are considerably different than the following three formulae. Other projects may show substantially different results. The selection of the formula will depend on the project specifics and the spend rate for the remainder of the project. The project manager and the control account manager are usually tasked to make this choice.

Table A.2: Summary of EAC calculations

EAC formulae	EAC	VAC
EAC = AC + ETC	EUR 590 M	EUR -140 M
EAC = AC/EV × BAC	EUR 613.6 M	EUR -163.6 M
EAC = BAC/CPI	EUR 613.9 M	EUR -163.9 M
EAC = AC + [BAC – EV)/CPI]	EUR 613.8 M	EUR -163.8 M

Project management corrective actions

The owner/licensee project manager, working with the contractor's project manager and control account manager(s) would determine what changes were necessary to bring the project under control. This might include:

- technology changes to reduce cost and schedule.
- changes in work scope to eliminate unnecessary tasks.
- requiring the contractor to work overtime (at some additional cost).
- in extreme cases, discharging the contractor, calling its bond[1] and replacing it with a more qualified contractor.

Control account and work package completion computation methods

On most large projects like decommissioning, individual tasks (work packages) extend over several months. Determining the earned value can be a challenge in some cases. There are a number of methods to accomplish this, which include:

- fixed formula;
- milestone weights;
- milestone weights with per cent complete;
- units complete;
- per cent complete;
- level of effort.

Fixed formula method

The fixed formula method applies to work packages and control accounts that span a short period of time (within an accounting period, < 3 months). This method applies a per cent complete to the start and finish of an activity. Generally, the percentages used in the formula are 0/100, 50/50 or 25/75:

- 0/11 – Nothing is earned when activity starts but 100% of budget is earned when completed.
- 50/50 – 50% is earned when activity starts and the balance is earned on completion.
- 25/75 – 25% is earned when activity starts and the balance is earned on completion.

Milestone weights

The milestone weighting method assigns budget value to each milestone. Upon full completion of each milestone the budget is earned. Milestone weighting is used for work packages with long durations and ideally should have milestones each month or accounting period. Nothing is earned until the milestone is completed, which means the contractor will receive no credit (payment) until the next or subsequent period.

For the contractor, it creates payroll problems unless the contractor has many other work packages in process with successfully completed milestones. For the project manager, it simplifies determination of earned value as no judgmental or uncertainty is involved. However, it requires well-defined milestones.

Milestone weighting with per cent complete

Milestone weighting with per cent complete assigns budget value to each milestone, and is earned based on the per cent of work completed against each individual milestone. This method is used for work packages with long durations and should have milestones each month or accounting period.

The per cent completed may be determined on the basis of material removed for the milestone. For example, if the milestone is to remove all piping from a given work area, amounting to say 500 meters of piping, the control account manager (or his designee) will work with the contractor's project manager to estimate the amount of pipe actually removed during the reporting period. So if 70% is removed, the contractor will have earned 70% of the value of the milestone, or the value of 350 meters of pipe.

1. A performance and payment bond is often required to guarantee the work of a contractor. The additional cost to a project is usually justified.

There is always some amount of negotiating involved to reach agreement, but if the contractor overestimates the per cent removed, the contractor will have to make it up during the next reporting period with no additional payment. The contractor will have to explain in his progress report why he missed the milestone completion, and what the contractor will do during the next period to get back on schedule. This is where accountability plays an important role in earned value!

Unit(s) complete

The unit complete method uses a physical count to determine what is earned. To use unit complete there must be units that are identical or similar and they must have the same budget value.

For example, if a work area contains 10 tanks of approximately the same size and complexity (and cost) for removal, the value will be earned when all 10 tanks have been removed. If only five tanks are removed during a reporting period, the contractor will get credit for only 50% of the earned value.

The same consequences are faced by the contractor as in the previous example, with an explanation of why the contractor missed the milestone and what will be done during the next reporting period to make up the delay in schedule.

Subjective per cent complete

The subjective per cent complete method applies a per cent complete to a budget value to determine what is earned. The per cent complete value is determined by the control account manager (or his designee) and the contractor.

This method might apply for the preparation of detailed procedures needed for a subsequent activity. The amount of work for each procedure might vary with complexity, or may depend on the project manger's approvals needed for acceptance. Another situation may arise where the contractor's work depends on the availability of a major crane that is also being used by other contractors with higher priorities.

The subjective decision as to per cent complete may be a negotiated amount each reporting period. The control account manager must maintain documented logic of the method used for each reporting period, and milestones generally do not apply.

Level of effort

The level of effort (LOE) method is based on the passage of time. A monthly budget value is earned with the passage of time and is always equal to the monthly planned amount.

When using LOE, the planned value (BCWS) is always equal to the earned value (BCWP). The earned value would be the same for each reporting period, and the per cent complete would be the per cent complete for that phase. The actual cost (ACWP) would be determined from the accounting records.

For example, programme (or project) management would depend on the management staffing level for a phase of decommissioning. The contractor's (or owner/licensee's) staff costs are fixed for the periods of the phase, and the contractor (or owner/licensee) would earn the full value for that reporting period.

The only challenge would be whether the size of the staff is needed for that phase. This is generally agreed upon early in the project so that monthly or periodic negotiations are unnecessary.

This earned value method should be kept to a minimal number of work packages.

Summary

This session presented the EVMS computations for the performance measurement baseline, control accounts and work packages and showed how to evaluate the results. The computations shown are all included in modern accounting software, and reports are available bi-weekly and monthly for the project manager's review and action. With these results, early indications of problems areas can be determined and corrective action applied.

Training Session V – Integrated baseline review, change control and reporting

Scope of Session V

The objective of this session is to consider programme reviews, changes to the programme (or projects) and reporting requirements. Specifically, this session will cover:

- integrated baseline reviews;
- change control;
- reporting formats and requirements.

Integrated baseline reviews

The purpose of an integrated baseline review (IBR) is to:

- verify the technical content of the performance measurement baseline (PMB);
- assess the accuracy of the related resources (budgets and schedules);
- identify potential risks.

An IBR is usually performed initially within six months of contract award, or when a modification to a contract changes the performance measurement baseline. The IBR is intended to be a continuous part of the programme by both the owner/licensee and the contractor(s).

The objectives of the integrated baseline review are to:

- ensure that the technical content of control account, work packages and planning packages is consistent with the contract work breakdown structure (CWBS) and the contract statement of work (SOW);
- ensure that a logical sequence of effort planned is consistent with the contract schedule;
- assess the validity of allocated budgets in terms of work content, resources and time-phasing;
- understand the earned value methods for measuring accomplishment (work package per cent complete), and to verify that objective and meaningful performance data is provided in terms of technical accomplishment;
- verify that effective variance analysis processes are applied to identify, correct and report problems including cost and schedule impacts;
- verify that proper accounting cross-checks are established so cost account data is accurately reflected in reports to the owner/licensee;
- verify that cost, schedule and technical systems are integrated;
- establish a forum through which the owner/licensee programme manager and the programme technical staff develop a co-operative relationship, and gain a sense of ownership of the cost/schedule management process.

The following documents are typically provided by the contractor to the owner/licensee for the IBR:

- statement of work (SOW);
- CWBS dictionary;
- control account plans;
- variance thresholds for reporting;
- undistributed budget logs;
- EV methods (fixed through LOE);
- organisational breakdown structure (OBS);
- contract work breakdown structure (CWBS);
- work authorisation documents;
- baseline schedule;
- management reserve logs (record of withdrawal);
- responsibility assignment matrix (RAM);

- earned value measurement criteria (% complete).

The initial submittal will be a significant effort, but subsequent reviews will be easier if there are no substantial changes.

Change control

As noted earlier, the performance measurement baseline (PMB) is the time-phased budget plan against which contract performance is measured. Performance measurement data require a documented PMB, which reflects the most current conditions of the programme.

Once the performance measurement baseline (PMB) is established or "frozen", cost and schedule changes are processed through formal change control procedures. Authorised changes must be incorporated into the PMB in a timely manner and reflected in both budgets and schedules.

The change control process is used to establish, analyse, communicate and record approved changes to the programme baseline.

The objectives of a change control process are to:

- Document, track and communicate changes to the performance measurement baseline.
- Reconcile current budgets to prior budgets for changes to the authorised work in the detail needed by management for effective control.
- Control retroactive changes to records pertaining to work performed that would change previously reported amounts for actual costs, earned value or budgets.
- Adjustments should be made only for correction of errors, routine accounting adjustments, effects of customer or management directed changes or to improve the baseline integrity and accuracy of performance measurement data.
- Prevent revisions to the programme budget except for authorised changes.

Baseline changes may occur as a result of:

- contractual changes/modifications;
- transfer of undistributed budget to distributed;
- the use of management reserve;
- re-planning (of a segment of a project);
- formal reprogramming (of the entire programme).

Changes will affect the following documents:

- cost performance reports;
- change control logs;
- revised work authorisation documents;
- management reserve logs;
- revised control account plans (no retroactive budget changes);
- revision request plans;
- revised statement of work (SOW);
- revised contract work breakdown structure.

Contractual changes are initially incorporated into the undistributed budget, and later transferred into the distribute budget (work plans).

Reporting formats and requirements

There are several reports which may be used for earned value management reporting and analysis. Each company or organisation may develop its own reporting method. The most commonly used report format for the US DOE, for example, is the cost performance report (CPR).

Cost performance report

The cost performance report (CPR) is the most comprehensive of the EVMS reports. It is normally a monthly report and has five different formats:

- Format 1 – Work breakdown structure (WBS);
- Format 2 – Organisational categories (OBS);
- Format 3 – Baseline;
- Format 4 – Staffing (manpower);
- Format 5 – Variance analysis report (with explanation and problem analysis).

Generally, all five formats are applied to a contract requiring EVMS. The owner/ licensee may not require all the reports and may delete one or more of them. To reduce paperwork, only the CPR Format 1 (WBS) and Format 5 (variance analysis report) may be required.

As noted earlier, most accounting software packages will perform the earned value calculations every two weeks as part of the payroll calculations. Copies of the US DOE Format reports are provided in Appendix B.

Summary

These five training sessions capture the core of the EVMS programme, following the structure below:

- introduction to EVMS;
- work breakdown, organisational structure and responsibility assignment matrix;
- budget, schedule and control accounts;
- earned value methods (per cent complete);
- integrated baseline review, change control and reporting.