11 SCHEDULING AND COST ESTIMATING

11.1 OVERVIEW

Schedules are used to plan and depict practical, time-phased, hierarchical activities and events. They contain activities, logical relationships, duration, resource requirements and constraints. Scheduling is inextricably tied to the technical baseline and are essential to developing a cost estimate for the technical baseline.

Development of schedules is required early in the project formulation and conceptualization phase. A preliminary schedule, including high-level milestones shall be established before completion of the preconceptual phase. An integrated project schedule should be in-place by completion of the conceptual phase for CD-1, Approve Preliminary Baseline Range. Detailed network schedules including milestones and critical path shall also be prepared and in place by completion of the conceptual phase. A project summary network schedule of the project shall be included in the final schedule baseline at CD-2, Approve Performance Baseline.

The integrated project schedule approved as part of the CD-2 approval will include, but is not limited to, the following:

- Activities related to the WBS and corresponding cost estimates
- Activities defined at the detail level and be logically sequenced to support, manage, and control the project
- The number of activities reflect a balance between number needed to define the project, and the ability of the control system to effectively maintain traceability
- Activity duration based on the number and availability of resources and, when appropriate, historical information
- The critical path, and capability to determine schedule float
- Milestones identified, defined, and related to baseline control levels
- Documented in a manner similar to the cost estimate, including basis, assumptions, exclusions, methodology, references, etc.

Cost estimates are required at various points in a project's life cycle. Determination of estimating methodology and approach will be based on the level and availability of scope definition and documentation, and the resources required for developing the cost estimate. Specific cost estimate requirements shall include:

- a planning estimate as part of the preconceptual phase.
- a preliminary cost estimate, including Life Cycle Cost analysis as part of the Conceptual Design Phase.
- a detailed cost estimate as part of the Preliminary Design.
- a Government Estimate for construction contracts.
- Independent Cost Estimates (ICEs) for all capital asset projects prior to approval of CD-2, Approve Performance Baseline.

  Independent Cost Reviews (ICRs) are typically conducted on all projects at the point of baseline approval. Independent reviews are an essential project management tool. Such reviews may be required by Congress, DOE management, Headquarters program offices, or field project management staff. The requiring office or agency will provide requirements for such reviews. Where possible, the ICE should be a part of an independent review.

For line item (LI), general plant projects (GPP), and capital equipment (CE) projects, cost estimates will address all costs associated with the project from conceptual design through project closeout. For Environmental Management (EM) projects, cost estimates will address all costs associated with the defined project life cycle. Where appropriate, EM cost estimates may include startup, operating, and decommissioning costs. Cost estimate contingency reserves shall be included in project estimates and baselines to allow for future situations which can only be partially planned at the current stage, e.g., "known unknowns." Contingencies included in cost estimates shall be based on risk assessments. Estimates, their content and methodology shall be consistent with Volume 6, Cost Guide, U.S. Department of Energy dated December 7, 1994.

ICEs are performed for all major line item acquisitions at appropriate points in the project life cycle. OECM works through appropriate contracting officers to establish contracts for ICEs. The ICEs are used to verify project cost estimates and support the CD-2 process in establishing project performance baselines. ICEs are documented in formal reports submitted to the SAE/AE by OECM. ICEs may be performed on different projects and at other times. Each ICE is reconciled with the current Program Office estimate by the project manager.

The initial basis for any cost estimate should be documented at the time the estimate is prepared. The basis should describe or reference the purpose of the project, the scope significant features and components, proposed methods of accomplishment, proposed project schedule, research and development requirements, special construction or operating procedures, site conditions, and any other pertinent factors or assumptions that may affect costs.

11.2 PURPOSE

This section is designed to provide guidance to achieve schedule and cost integration of all elements of the process, i.e., that critical path activities and milestones are visible, disciplined status techniques are employed, and effective reporting procedures are developed and implemented.

For the development and application of scheduling and cost-estimating methodologies, an integrated and disciplined approach is essential.

Cost estimating methodology should be consistent with the project phase or degree of project definition. An appropriate activity based cost-estimating methodology should be used (e.g., bottoms-up, parametric, estimating models, expert opinion, market quotations, etc.). The estimating methodology should be clearly specified along with assumptions made for determining the life-cycle cost estimates.

11.3 APPLICATION

11.3.1 Scheduling

Schedules are generally developed and presented in a hierarchical structure, with lower level detailed schedules being traceable to higher level schedules. Individual components or elements of work must be traceable from one schedule level to another to effectively portray a consistency. Schedules are developed consistent with the structure of the WBS to enable traceability and help integration of cost and technical baselines.

Schedule development and milestone identification involve identifying the specific activities that must be performed in order to produce the deliverables identified in the project's WBS. The work must be described accurately and understood by those who must perform the work. To help accomplish this activity, lists are

generated that include supporting descriptions for complete understanding. The activity list must include all activities that will be performed on the project. It should be organized as an extension to the WBS to help ensure that it is complete and does not include activities that are not part of the project scope.

Sequencing of activities involves identifying and documenting interactivity dependencies. Activities must be sequenced accurately in order to support the later development of a realistic and achievable schedule. Constraints on the start or completion of activities are identified. Certain assumptions are usually necessary for the establishment of a realistic, logically flowing activity sequence. These should be documented for discussion with the project participants.

Activity duration estimating is the establishment of realistic times to complete the identified activities. The individuals or groups most familiar with, or responsible for, a specific activity should estimate or approve these times in order to provide the most reasonable duration. Integration with cost and resources planning is generally required, e.g., determining what resources (people, equipment, and materials) and what quantities of each should be used to perform project activities.

Schedule development means determining start and finish dates for project activities. If the start and finish dates are not realistic, then the project is unlikely to be completed as scheduled. The schedule development process must often be iterated (along with the processes that provide inputs, especially duration estimating and cost estimating) prior to determination of the project schedule.

Schedule development will also consider allowances for future situations which can only be planned in part, e.g., “known unknowns” will occur. Schedule contingency shall therefore be a legitimate allowance and like cost estimate contingencies shall be analyzed and planned for based on an assessment of scheduling risks. Contingency shall be incorporated into the project baseline.

Pertinent schedules should be critical path method (CPM) schedules, resource loaded and leveled, and produced from precedence diagram method networks. Schedules should be reviewed and their status provided regularly; preferably at least monthly.

On large projects, an ongoing assessment and coordination of activity progress and analysis of dynamic critical path is essential to ensure participants adhere to their schedule baselines to achieve planned completion dates. The overall project schedule must have the capability to account for progress on a contract-by-contract basis for multiple contract projects.

Use of progressively lower-level networks are necessary for analysis of the schedule interfaces between major participating contractors through a schedule hierarchy. Schedule delays in one contract may impact other contractors and may significantly disrupt resource availability, affect budgeted costs and impair progress. Figure 11-1 illustrates a suggested schedule hierarchy for large projects with multiple participants and multiple scheduling databases. The schedule hierarchy is used for tracking progress and for identifying potential technical issues, areas needing further activity planing, areas of schedule uncertainty, budget issues, activity progress trends, and critical path issues.

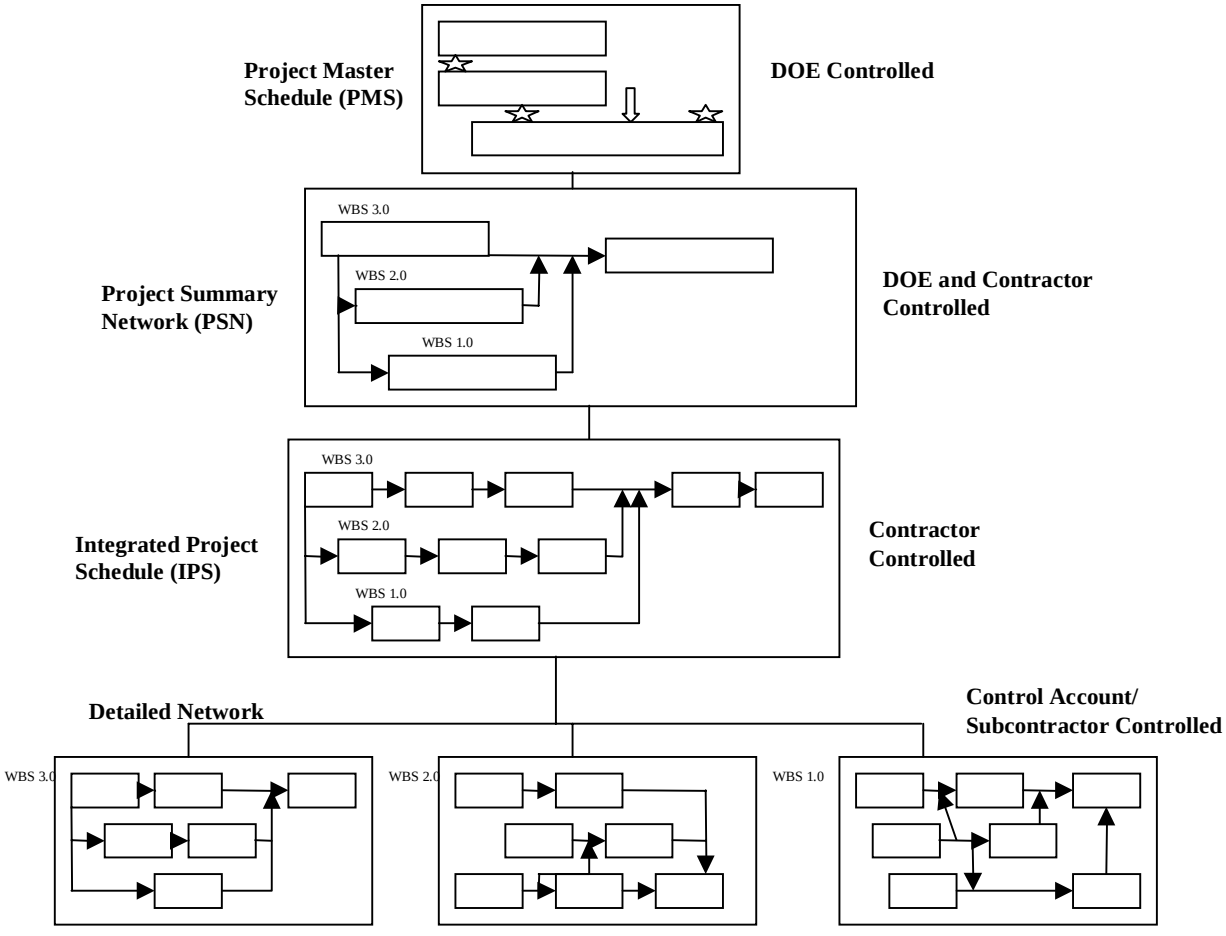

Figure 11-1. Project Schedule Hierarchy

The project master schedule (PMS) is a summary activity bar chart with correlating milestones. All DOE controlled milestones are depicted. Identification of external milestones (e.g., Tri-Party Agreement milestones) should also be depicted. The master schedule is used by management as the primary tool to monitor and control the project schedule baseline. The master schedule illustrates the most significant schedule "drivers" (i.e., influences) affecting project completion.

The project master schedule is the controlling project schedule, and each revision must be signed by the project manager. For example, once the scheduled baseline has been established, logic link adjustments will be necessary to optimize the critical path or correct activity sequencing. Even though such adjustments are considered schedule maintenance and may not require board approval, caution must be exercised when making logic-tie changes since a simple change may have a significant impact on budget-time phasing or projected completion of a baselined milestone.

The project summary network is an aggregated activity and logic network that illustrates the primary logic links between summary activities in higher WBS elements. It summarizes sequences of activities within a high level WBS (usually WBS level 2) and recognizes significant logic links between WBS elements. The project manager shall use the project summary network to monitor and control work scope that is on the critical path.

The integrated project schedule is the single schedule network database by which all project cost and schedule plans and performance is measured. It represents the detailed planning for the project and is used as the project's cost and schedule status mechanism throughout the life of the project. The integrated schedule and the master schedule are intermediate level schedules obtained from the same network database that provides greater detail than the master schedule. The integrator uses and maintains the integrated project schedule to control all project work. The contractor's functional managers (i.e., design engineering, construction management, and other groups) use the integrated project schedule to plan and monitor the completion of their scopes of work.

Detailed schedule networks are developed for individual scopes of work and WBS elements at a more detailed level equivalent or below the integrated project schedule as necessary. Detailed schedule networks should avoid too much detail that will be an unnecessary burden to maintain. These networks may be developed by cost account managers and/or by subcontractors for their scopes of work or functional area (i.e., design engineering). The primary purpose for detailed schedule networks is to allow the functional areas or subcontractors to plan and

control their scheduled activities in parallel to the integrated project schedule. Each detailed schedule network is monitored and controlled by the managing (or integrating as assigned by the integrated project manager) contractor project manager and must integrate with the IPS to be considered a viable plan. The integration must include the activity logic, resources (when applicable), and progress status.

The integrated project schedule is contained in a database that can be coded, sorted or summarized to produce higher level schedules and specialized scheduling reports. Having the capability to selectively produce different types and levels of project schedule reports and graphic plots adds to the flexibility. Master and intermediate (i.e., project summary network and integrated project schedule) level schedules can be produced from the critical path method scheduling database as required by management. The project should produce schedule diagrams and reports from the critical path network database that correspond to a specific level of the WBS.

On projects with minimum planning and scheduling requirements (e.g. small line items and general plant projects), the scheduling can be satisfied with start and complete milestones for project phases and summary bar-chart schedules.

Projects with moderate planning and scheduling requirements should include DOE Headquarter and field office controlled milestones, formal milestone definitions, (e.g., dictionary), and a CPM schedule.

Projects with high schedule risk should have additional system data, which include more DOE-controlled milestones, formal milestone definitions (e.g., dictionary), CPM schedule, and resource or dollar-loaded schedules.

11.3.2 Cost Estimating

Cost estimates must be prepared in a clear, consistent, comprehensive format that facilitates review of details and assumptions throughout the cost estimate review process. Activities to be estimated shall be identified in sufficient detail to support the cost estimate methodology used.

The estimate details must clearly indicate the productivity factor used and the actual unit rates from the national or reviewed site database.

Cost estimates must have backup documentation in a centrally located program file that explains the assumptions and calculations upon which the estimate is based.

The development of activities is driven by the project scope. Defining an activity includes the concept that it is a measurable unit of work. Necessary elements for activity definition are that it is measurable and is defined in terms of work output and not labor hours to perform. Each activity needs to have an identifiable unit of measure and, if appropriate, discrete quantities associated with that activity.

The appropriate level of detail will depend on the potential for error or savings, and the maturity of the project being costed. As a project matures, scope, documentation, and the estimate can become more detailed based on more readily available cost, schedule, and other project data. Considerations for determining the estimate detail include

- the level at which costs are to be collected (as a minimum).
- the level at which performance is to be evaluated.
- the repetitiveness of the activity.
- the dollar value of the activity and the potential for large or long-term savings.
- the level at which accurate cost data is available (historical costs, unit of work databases, costing methodology, etc.).

A WBS and WBS dictionary for each project should be included with the cost estimate. The dictionary should identify all activities for which costs were or are planned to be estimated. The WBS is a hierarchical system of defining where the elements of work scope, cost, and schedule meet and the structure against which they are compared.

For major projects and other projects, cost estimates will address all the costs associated with the project from preliminary design through the closeout phase. For Environmental Management, project estimates will address all costs associated with the project life cycle, as appropriate. EM cost estimates may include startup, operating, and construction costs. Contingencies included in cost estimates shall be based on risk assessment.

Cost estimates shall be prepared using appropriate estimating methodologies. Estimates for all contract work should be consistent with the WBS, and the DOE cost structure as specified by the DOE. The project must ensure that all estimates are consistent with DOE Order 5700.2D, Cost Estimating Analysis, and Standardization, and with FAR clause 15.804, Cost and Price Data Analysis, as applicable.

Estimating the cost of a project in accordance with DOE standards is required by DOE O 413.1. The DOE places importance upon the accuracy and validity of project cost estimates since they are the basis of funding requests and project cost and schedule baselines. DOE O 413.1 and DOE Order 5700.2D require that cost estimates be developed and maintained throughout the life of each project, using the most appropriate estimating technique.

A thorough understanding of the work scope is necessary to effectively estimate costs. The project cost estimate, after approval of the conceptual design, is also the basis for a DOE funds request to Congress and a budget authority to execute the project's work scope. The contractor's budget is time-phased according to funds and contractor resource availability. After the WBS is defined, the cost estimate is integrated with the activities and schedule logic for each WBS element. The level of detail in the estimate must be low enough to provide confidence in the estimate's value to plan funding requests and also to facilitate the calculation of control account resources and schedule activity durations.

A project's cost estimate must integrate with the scope, schedule and cost baselines. The estimate is the basis of the project's cost baseline. Estimate integration with the WBS occurs when the scope in each WBS element has a specific and identifiable estimate of cost. In addition to the WBS requirement, the cost estimate must be developed in accordance with other project related requirements specified by DOE, such as the DOE Cost Breakdown Structure, Project Data Sheet, Activity Data Sheet, etc.

The project shall prepare estimates, as applicable, in accordance with established project phases, maintaining a distinction between Total Estimated Cost (TEC), Other Project Costs (OPC), which are the non-TEC costs, and Total Project Cost (TPC). The project must also maintain an appropriate cost estimating capability to accommodate project estimates-to-complete (ETC) and estimates-at-completion (EAC).

Throughout the phases of a project, reassessments of the cost estimate will be made as specified by the project manager. The capability must exist to calculate TPC, and cost estimates must have the ability to distinguish between TPC, TEC, and OPC, as defined in DOE Order 413.X. Most projects will be required to provide a revised estimate-to-complete (ETC) on an annual basis. The ETC is an estimate of the cost and time required to complete a project's remaining effort including estimated cost of authorized work not yet completed and authorized work not yet estimated; it is generated in conjunction with the current project

schedule. The ETC is a major component of the estimate-at-completion (EAC) which represents the total project cost at the completion of the project. The EAC includes cost-to-date, an ETC, and an estimate of claims liability. Requirements for the frequency of an EAC can be based upon the significance of project cost and schedule variances, project delays due to funding shortfalls or other project constraints, or significant project scope changes. The DOE project manager will consider the need and timing for an EAC and will provide such guidance to the contractor.

The cost account manager who forecasts any at-completion variances performs ETCs and EACs on a more frequent basis at the cost account level. The cost account manager should give particular attention to accounts that are developing unfavorable trends.

Escalation is an allowance to offset the impact of monetary inflation on the current estimated cost of an activity. Escalation is used to estimate the future cost of a project or to adjust historical costs to the present value. Escalation rates are developed by DOE HQ and provided to the field. These rates are to be used for all cost estimating unless otherwise specified in the Project Execution Plan.

Contingency is an allowance based on a valid and documented risk analysis. It is included as part of the total estimated project cost to provide for costs that may be incurred due to incomplete design or other unforeseen or unpredictable conditions. The amount of contingency is based on assessing the degree of risk or uncertainty associated with all remaining project activities.

11.4 TAILORED APPROACH

As a minimum, all projects shall have a cost estimate that is developed from a documented DOE approved work scope as the basis for the project cost and schedule baselines. Cost estimate levels of detail, techniques, review or approval, and review frequency will vary with the size of the project and the degree of project risk determined. The project risk assessment will influence cost estimating precision and detail needed by evaluating factors such as the type of work (from research to construction) and schedule phase (preconceptual design to construction or clean up).

Contingency shall be risked-based and be assessed for the entire project. It is generally developed at lower component levels as deemed necessary by the project manager.