LIFE

CYCLE

ASSET

MANAGEMENT

Good Practice Guide
GPG-FM-016

Baseline Development

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1. INTRODUCTION

This Guide was developed for the implementation of Department of Energy (DOE) O 430.1, LIFE-CYCLE ASSET MANAGEMENT (LCAM). It should help program and project managers develop project baselines that can be used to streamline the processes of project review and tracking. This Guide may apply to all types of projects, including conventional construction, construction of scientific facilities, rehabilitation projects, environmental restoration, waste management, and decommissioning and decontamination (D&D).

A project baseline describes a desired end-product and associated schedules and costs. Development and use of baselines is a good management practice for five principal reasons: (1) to ensure that project objectives will be met; (2) to manage and monitor progress during project execution; (3) to define the project for approval and authorization within DOE by the Office of Management and Budget (OMB), and by the Congress; (4) to ensure accurate information on the final configuration (as-built drawings, specifications, expenditures, etc.); and (5) to establish performance measurement criteria in performance-based contracts.

Although project baselines should be established during the conceptual project phase, baseline development should continue throughout each phase of the project, with more detail added at each step.

Project baselines should be reaffirmed at each major decision point and at "critical decisions" for strategic systems. For other projects, reaffirmation should occur at the equivalent decision points, especially prior to commitment of significant resources. In addition, baselines should fit into the Congressional budget cycle to ensure that information submitted is accurate and up to date.

The level of detail involved in developing a project baseline depends on the nature of the project. A graded approach should be used commensurate with:

- the size and complexity of the project,
- the uniqueness of the project and the use of new versus proven components and processes,
- project visibility and sensitivity,
- the extent to which the activity is already covered by contractual requirements, and

- other risks (see *Risk Analysis and Management*, GPG-FM-007, for further discussion).

The graded approach is used to ensure that excessive, inefficient, and inappropriate management requirements are not imposed on a project. Large and complex projects or programs (e.g., strategic systems) usually require highly developed baselines. Smaller projects usually require lesser detail.

2. PRINCIPLES AND PROCESSES

A project baseline contains three elements: (1) the technical baseline, (2) the cost baseline, and (3) the schedule baseline. The technical baseline is developed first and describes the desired configuration, performance, and characteristics of the end-product. The scope of work necessary to provide the end-product is determined using the technical baseline. The scope of work is divided into elements that become the work breakdown structure (WBS) and are the basis for the schedule and cost baselines. WBS elements are very tightly coupled, and a change in one baseline may affect one or more of the others. The WBS itself is hierarchical in the sense that each element in a WBS may be subdivided and becomes the basis for the next lower, more detailed WBS level.

Initially, few details appear in the baseline. It may include only the performance directly related to program mission, some bare specifications, and an outline of the technical approach. During concept development details are added, including end product and critical subsystem specifications and drawings. For environmental cleanup, the initial performance and specification details will focus on cleanup standards, requirements, and the regulatory and compliance drivers involved.

Baseline detail and precision increase as a project progresses. For conventional construction project phases may include concept development, preliminary design, detailed design, and construction. (See Figure 3.1-1 in *Project Execution and Engineering Management Planning* [*PEAEMP*], GPG-FM-010.) For environmental restoration, this is usually assessment and design. During early project phases, baseline development may be iterative if costs or schedules do not meet expectations; this may require redetermination and rescheduling of the technical baseline or scope of work. During operations and project closeout, there is seldom any change to the baseline or the level of detail.

The history of the maturing baseline is recorded through systematic configuration management, which provides a reference for managing and evaluating the project. Configuration management ensures that changes are made only after adequate review and that there is an audit trail of the reviews and changes. The process of change control is distinct from the process of developing the baseline itself. The process in this Guide address only development of the baseline itself; a separate Guide describes the change control process, namely configuration management (see *Configuration and Data Management*, GPG-FM-012, for details).

2.1 Specific Project Requirements

Specific types of projects, such as research and development or environmental projects, have unique characteristics that should be reflected in their baselines. Such projects may be dependent on innovative processes that are untried and unproven, with numerous and complex alternatives considered. The common characteristics of such projects are high technology risks, R&D for the project, evaluation of alternatives and non-routine activities, and flexibility to schedule delays and fall-back activities as needed. As a result, technology development, flexibility, and risk analysis in both technical development and project execution should be an integral part of cost and schedule baselines.

The major components of these projects should provide as appropriate: (1) specific plans for integrating research and study efforts into the overall project, (2) alternative plans for problematic operations or components, (3) procurement risks for one-of-a kind items, (4) supplier capacities, and (5) uncertainties of first-time operations.

Environmental projects may have unique characteristics including: (1) ill-defined technical requirements early in the project life, (2) uncertainty about when to formulate baselines, (3) compliance and hearing requirements involving many stakeholders, (4) numerous subproject, many of which are unrelated but tied together to facilitate administration), (5) large variances in the estimating accuracy due to uncertain scope or requirements, and (6) social and political considerations. To simplify matters, consideration should be given to baselining in two stages: separately for the assessment and again for the remedial action. Given the typically high number of subprojects, they may be baselined individually and in stages.

2.2 Baselines

As mentioned above, a project baseline contains three elements: technical, cost, and schedule. These elements should be fully integrated in the WBS and developed to appropriate levels of detail.

2.2.1 Technical Baseline

Initially the technical baseline is derived from program or mission requirements. Baseline maturation is supported by the increasingly detailed studies resulting from improvements, changes, increased understanding, or problems encountered. During each phase the technical baseline must contain enough detail to support the scope of work and the cost and schedule baselines.

The technical baseline defines the desired end-product and includes at a minimum:

- specifications (for environmental projects, this may be a Work Breakdown Structure Dictionary),
- drawings, and
- performance requirements.

A more detailed list may be found in *PEAEMP*, GPG-FM-010.

2.2.2 Cost Baseline

The cost baseline is based on validated or independently verified project cost estimates. During concept development, the cost baseline may consist of a single cost figure for the entire project. Later on, for most large systems the baseline will be broken out for the major subsystems (the first level of the WBS) and often for a particularly critical or risky subsystem.

The cost baseline should reflect all capital and expense funds required from conceptual design to beneficial occupancy, including any outside funds. This baseline also should factor in the approved escalation rates. Project contingency is a separate part of the cost baseline since performance is not tracked against contingency and contingency is not allocated to the contractor except through change control.

Life-cycle costs (LCC) because they begin with beneficial occupancy, although those costs, through tradeoffs, may influence design or other options and, hence, the project baseline.

Although the cost baseline helps control the project, its detail will probably not match that desired by the contractor. An intermediate level of detail may serve for variance reporting, performance assessment, and earned progress payments. However, since the baseline and such details are drawn from the same estimates, they will be closely related.

2.2.3 Schedule Baseline

A schedule baseline (including critical path definition and milestones) should reflect all project requirements including programmatic, operational, legislative, site, regulatory, compliance, and institutional constraints. The baseline components should correspond to the WBS. This baseline will facilitate project planning and the identification of time-phasing and logic relationships among subsystem activities and with other projects.

In addition the baseline should help determine critical project activities and performance measurement criteria. It should specify the time needed to complete the work scope elements, reach project milestones, and complete the project. Milestones should be distributed evenly through time, so that all phases of a project can be adequately tracked. The baseline may be resource-loaded as needed at the appropriate level to facilitate budgeting; however, care must be taken to prevent budget profiles entering the controlled baseline in excessive detail.

The amount of detail provided should be commensurate with the nature of the project. Activities related to the achievement of a milestone should be identified and sequenced, appropriate durations identified, and float allocated systematically. During schedule baseline development, flexibility should be allowed for scheduling contingencies in response to risks, other problems, or delays.

2.3 Defining the Basis of Assumptions

The assumptions made when formulating a project or baseline should be defined in the work scope, schedule, or cost documents, a risk analysis document, or in a separate assumption document. Principal constraining factors should also be included. Alternative actions should be indicated if key assumptions prove false. Typical assumptions at the programmatic level and for technical/project-specific areas may be found in *Performance Analysis and Reporting*, GPG-FM-006.

2.4 Technical Baseline Development

2.4.1 Technical Baseline

The first step is to translate mission needs or environmental risks into the technical baseline based on assessment of available technology, preliminary site evaluations or observations, and relations with other programs and site activities. This process is also detailed in the *PEAEMP* Guide (GPG-FM-010). The baseline should provide the following information. Several iterations of the following may be required before the alternatives and their requirements are settled.

- Weaknesses or needs derived from program mission and objectives. For environmental projects, gradually increasing levels of detail and accuracy will determine the nature of problems (e.g., the need for remedial investigation). In either case, where knowledge is lacking it must be sought.

- Alternative ways of meeting needs.

- Interfaces (existing and potential) among the DOE activities, programs, and projects (see *Interface Management,* GPG-FM-013).

- Requirements of the potential alternative projects.

- Decision criteria for tradeoff studies.

- Tradeoff Studies performed to select the preferred architecture (see *Engineering Tradeoff Studies*, GPG-FM-003). For environmental projects, this process is a formal requirement and includes specified documents, hearings, etc.

The technical baseline gradually evolves into subsystem requirements, drawings, specifications, and performance and manufacturing procedures as applicable (usually where state of the art is involved). Eventually the baseline identifies the physical systems for each subproject or facility, the boundaries and interfaces for each physical system, and the major components for the physical systems.

Prior to start of construction, cleanup, assessment, manufacture, assembly, installation, or test of the systems or components, the level of detail should include component drawings, detailed performance and specifications, cleanup standards, test and inspection procedures, and operating and maintenance manuals.

The extent to which these components are spelled out in the technical baseline is dictated by the graded approach. For all projects there is a minimum level of control required, such as drawing change control. Ordinarily, control of drawing and other changes resides with the contractor. As part of the graded approach, the change threshold at which higher echelons review or approve changes depends on the nature of the project.

2.4.2 Use of Specifications in Baseline Development

Technical requirements should be documented in a specification (or WBS dictionary for environmental projects). The *PEAEMP* Guide (GPG-FM-010) describes different types of specifications. The best reference for what a specification should contain is "Specification Practices," MIL-STD-490A, June 4, 1985. DOE applications may select from the guidance in MIL-STD-490A, and the provided outlines also may be used as a checklist to make sure nothing is missed.

A specification can be very simple: for example, a page describing the performance and function of a component. Most equipment vendors use this type of specification in marketing their products. A system, however, requires a more detailed specification; for example, the functional units, the functions to be performed, the requirements for the functions, the interface with other systems, the design and construction or manufacturing criteria and subsystem requirements, and test requirements.

The *PEAEMP* Guide discusses the division of the mission needs into manageable functional units. Often each functional unit requires its own technical requirements and design criteria, documented in a specification. This is especially true when the unit or work scope is to be provided by another organization, such as another part of DOE, another Program Office or Site, or a contractor or subcontractor. Selecting the hierarchy of specifications is one of the early and important tasks for a project team.

2.5 Cost Baseline Development

Four major project management elements are prerequisite to developing the cost baseline and time-phasing the costs: work scope, WBS, project schedule, and a verified project cost estimate.

The WBS is most often based on institutional practices and fleshed out from the work scope and technical requirements. Each WBS element defines or describes some component of the work scope or technical requirement. In environmental projects, the WBS dictionary may contain the scope, but it also includes other details such as the technical baseline. In construction type projects, the dictionary (if any) only supplements the technical baseline. The WBS divides the work into manageable packages compatible with estimating, scheduling, and completing the project. It links the cost, schedule, and scope and facilitates work planning at the appropriate level of detail. It must contain all of the work scope.

The project cost estimate is the basis for the cost baseline. The estimate should include all capital and expense funds required from conceptual design to beneficial occupancy, including any outside funds (such as foreign, university, or other agencies). The estimate "prices out" the work scope, which is organized around the WBS. Scope peculiarities (for example, subcontract interface requirements) should be carefully addressed and documented in the project estimate.

Site-specific cost guides and/or *DOE Cost Estimating Guide*, *Volume VI* (DOE 1994), should be consulted for estimating procedures to develop the following information for the cost baseline: (1) when estimates are needed, (2) preparation procedures, (3) responsibilities, (4) documentation and traceability requirements, and (5) special requirements for individual components (construction, startup, direct, fees, contingency, project closeout, etc.).

During the preconceptual, conceptual, or early assessment phase of a project, cost estimates will be of planning quality and not as refined later, so cost estimating relations and general estimating tools may be used. In the design phases, the estimate should contain significantly more detail, including significant site-specific costs; it should be more accurate and be based on quantity take-offs and other detailed design parameters.

The estimate developed during the conceptual phase becomes the cost baseline used to manage and control the project during most of its life. Therefore, such estimates should be verified independently. The graded approach and the project's stage of development will dictate the level of detail appropriate for the estimate. The detail of initial estimates may not match the level of detail of the cost control desired during project execution; therefore, early project planning will expand the level of detail.

Each subsequent cost estimate should be compared with previous estimates. Explanations of changes should be documented and kept on file until project completion. Estimate files should include the basis for the estimate, including historical and other data and procedures.

The ownership component of the estimated LCC—the operational and closeout phases (D&D and other costs) of an acquisition or facility—are required for alternative evaluation, tradeoff studies, and outyear budgeting, thereby helping to establish the baselines. Costs for the later ownership phases are not as accurate as for the acquisition costs (though they should at least be planning quality), so only radical changes of these components of LCC might cause previous decisions and choices to be reconsidered. Even though ownership LCC components are considered in design, they are not part of the project baseline because they occur after project completion.

The cost baseline includes escalation and contingency, so too must the estimate based on the approved escalation rates and time phasing. Costs are time phased using the project schedule, and usually at the level of detail supporting regular variance reporting, performance assessment, and earned progress payments.

Project contingency is usually estimated for subsystems and rolled up so that it can be maintained in a project pool. Methods for estimating contingency and rolling it up can be found in the references.

2.6 Schedule Baseline Development

Generally, four levels of detail are possible to develop schedules and delineate management and control levels:

1. Project Master Schedule - DOE Program (and ESAAB) controlled
2. Project Summary Network - DOE project manager controlled
3. Integrated Project Schedule - Contractor controlled
4. Detailed Schedule(s) - Contractor controlled

The first or top level has the fewest details. Each lower level is in greater detail, reflecting subdivisions in lower WBS levels, and supporting the upper level schedule. Milestones link the detail levels in the schedule hierarchy. Milestones from the top level should be included in all lower level schedules so that status can be traced from the lowest to the highest level schedule.

The **Project Master Schedule** is used by the DOE Program Office and ESAAB to track the highest level of milestones in the baseline. This schedule is a summary level bar chart or time-phased diagram of all DOE Program-controlled milestones. This top level schedule should be based on an analysis and determination of mission and program requirements and external constraints. All requirements and constraints affecting the schedule must be identified and planned for, whether or not costs can be associated with them. Such constraints may be key decisions, delivery requirements, regulatory milestones, or other commitments. External milestones should also be included in this schedule as appropriate. These may include regulatory milestones, involvement from other agencies, interface points, etc.

The **Project Summary Network** summarizes activities from WBS elements, the Project Master Schedule, and milestones defined by the DOE project manager. This schedule is used by the DOE project manager to monitor schedule progress and performance, and control work that is on the project summary critical path. The Project Summary Network is appropriate for costing or resource loading and to examine alternative funding and cost scenarios. All external milestones should be included.

The **Integrated Project Schedule** is the primary schedule from which schedule performance is managed, measured, and reported to DOE by the contractor. It is used to determine schedule status and project performance. It is used for detailed integration and coordination among project activities or WBS elements. It contains the project critical path. The Project Summary Network and Project Master Schedule can be generated through computer sorts and summarization of this schedule.

Detailed Schedules allow contractor control account managers, functional managers, and subcontractors to plan and control networks and work scopes under their cognizance and coordinate them with the Integrated Project Schedule. Detailed schedules may not be developed for all projects, but if they are they may not be visible to the DOE project manager.

The number of levels of scheduling detail used in planning and baseline development is graded, typically depending on project size, complexity, and other risk. Schedule development can start at the top level or at a lower, more detailed level. Usually it begins with the top level—because external requirements are known and details needed for the lower levels are not immediately obvious—and gradually extends to lower levels, with more detail. Either way, the process may iterate between upper and lower levels so that external requirements can be supported by adjustments to the planning inherent in the lower echelon schedules, or the external requirements have been negotiated to match planning feasibilities.

At the lower level schedules, elements of the WBS must be analyzed to establish order and sequencing relationships. The duration of each element will be determined from typical resource allocation. The total project time required will depend on the durations and sequencing. This analysis may be repeated at lower level schedules, to verify the top-level calculations, and iterated as needed.

Detailed scheduling accommodates resource planning and identifies discrete work units that can be managed and controlled. Management is facilitated because expected costs associated with each schedule element completed can be compared to actual costs constantly, providing independent and early identification of problem symptoms which then can be addressed promptly.

2.7 Work Plans

Once the project baselines have been established and the DOE project manager has authorized work and funds to the contractor, detailed work plans and preparations for execution can be completed by the contractor. These plans have two components: schedule and cost. In addition, resource-loading—a relation between schedule and an aspect of cost—may be included.

2.7.1 Schedule

The selection of DOE-controlled milestones is an important responsibility for the DOE project manager. Milestones signify the start or completion of significant activities, work scopes, technical objectives, or project phases. The DOE-controlled milestones are the basis for effective reporting and control of schedule performance. Milestones should be spaced to allow regular determination of progress.

Milestone selection should be based on two needs: monitoring the achievement of technical objectives and monitoring the contractor's progress. Milestones to monitor technical objectives should focus on progress toward the overall project technical objective or interim technical objectives that support ultimate completion. Frequently, there are decision points at critical junctures of a project. These decision points may result in "go/no-go" or fall-back decisions based on actual versus expected performance. Proper selection of these milestone is critical to DOE project management decisions.

Milestones that help DOE project managers monitor contractor progress should be scheduled at the start or completion of discrete activities. These milestones help DOE project managers ensure that the contractor is making progress not only against the schedule for project completion but along the way. These milestones can also serve as integration control points when multiple contractors are involved.

Appropriate schedule contingencies for a project are best determined from risk analysis, which reveals unknowns, assumptions, and other factors that may create a potential for risk. In response, the project team determines appropriate schedule contingencies, thus allowing the flexibility to manage or mitigate the risks.

There are several basic methods for allocating schedule contingency: adding time to an event at risk, separating contractor milestones from the DOE-controlled milestones by time (dual milestones), or showing discrete activities that may be needed if a risk materializes.

2.7.2 Cost

The contractor normally develops the detailed work plans in what are called control accounts. These accounts reflect the level of detail within the WBS intended to be used by the contractor for management and control.

The knowledgeable control account manager, or the equivalent, develops detailed plans to perform assigned work. This is done by spreading the required resources over the necessary amount of time. How the resources are spread (that is, early, middle, or late resource priority) is at the discretion of the control account manager, provided the allocation is compatible with project requirements.

2.7.3 Resource Loading

Based on risk, size, or complexity, more detailed resource planning may be needed. Resource loading is a common method of planning. It assigns resources associated with the baseline cost for each WBS element with the time or period when that element is shown on the schedule. Resources can include the following:

- cost,
- personnel (full-time equivalent or headcount),
- job-hours,
- special or critical material (such as a batch plant concrete output),
- engineered equipment, or
- subcontractor resources

These resources can be loaded at different levels of the schedule hierarchy. For instance, dollars can be loaded at the summary level of the schedule hierarchy, or each labor category can be defined for each detailed activity in the network. Resource loading may also be used to forecast job-hour requirements or the need for leveling and coordinating the use of labor categories, special facilities (e.g., laboratories), or equipment.

Schedules can be resource-loaded to support resource leveling or scheduling, "what if" or fall-back scenarios, and to determine time-phased budget and spending profiles. Cost loading allows the DOE project manager to develop a funding profile with high confidence. "What if" or tradeoffs involve shifting work backward or forward and determining the impact on resource loading, total costs, schedule, or cost profile. This will assist in funding and schedule tradeoffs, budget requests, explaining the impact of funding shortfalls or shifts, and planning changes.

Resource-loaded schedules can be very useful in planning and managing a project, but should be used judiciously for a short or scarce resource, or for high risk, size, or complexity. Also, such details should not become part of the formal baseline to avoid micromanagement via configuration management.

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3. MEASURING FOR RESULTS

Systematic performance measurement of baseline development should be conducted for each selected project to facilitate timely, meaningful, and proactive monitoring. This performance measurement program should monitor the quality and utility of technical, cost, and schedule baselines, recognizing that the primary goal is better management and informed decision making, not just measurement.

In developing the metrics to grade performance of baseline development, the field elements and contractors should consider the following. (See also *Performance Measures*, GPG-FM-020.)

1. Are all baselines tied to the WBS.
2. Has scope been defined for all baseline elements.
3. Are the cost and schedule baselines traceable to the scope.
4. Is scope traceable and essential to the technical baseline.
5. Is the technical baseline traceable to the mission.
6. Is the level of baseline detail commensurate with the project phase and grading.

The metrics should focus on output and achievement of the overall output goals (as opposed to input or process) and avoid micromanagement.

The following four-step process is generally used in a performance measurement program.

1. Planning (identifying and defining the metrics).
2. Measuring achievement.
3. Comparing performance to goals.
4. Identifying corrective actions for poor performance.

As a project progresses through its life cycle, the performance measurement criteria will need to be periodically reviewed and updated. Metrics or criteria that are not being met should be reviewed to determine the reason for the variance and to identify corrective action whether it be a revision to the metrics or project work arounds. This review should involve all project team members and should also help identify problems or potential problems.

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4. SUGGESTED READING

The following documents provide additional information on baseline development or related topics.

1. DOE *Cost Estimating Guide, Volume VI, Cost Guide*, FM-50, November 1994.

2. DOE/MA-0040, *Cost and Schedule Control Systems Criteria for Contract Performance Measurement, Work Breakdown Structure Guide*, October 1981.

3. DOE/MA-0046, *Cost Estimating Manual*, January 1982.

4. OMB Bulletin 95-03, *Planning and Budgeting for the Acquisition of Fixed Assets*, June 1995.

5. OMB Circular A-109, *Major System Acquisition*, April 1976.

6. Project Management Guides

   - *Baseline Change Control*, GPG-FM-009
   - *Critical Decision Criteria*, GPG-FM-002
   - *Configuration and Data Management*, GPG-FM-012
   - *Performance Measures*, GPG-FM-020
   - *Interface Management*, GPG-FM-013
   - *Performance Analysis and Reporting*, GPG-FM-006
   - *Project Execution and Engineering Management Planning*, GPG-FM-010
   - *Risk Analysis and Management*, GPG-FM-007
   - *Engineering Tradeoff Studies*, GPG-FM-003
   - *Work Scope Planning*, GPG-FM-008

7. MIL-STD-490A, *Specification Practices*, June 4, 1985.

8. U.S. Congress, H.R. 826, Government Performance and Result Act, February 1993.

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5. DEFINITIONS

Project Baseline. A baseline quantifies projected costs, schedule, and technical requirements against which the status of resources and the progress of the project can be measured. Generally a project baseline consists of three components: costs, schedule, and technical baselines. These three baselines should encompass all key aspects of a project and should be fully integrated with each other.

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6. ASSISTANCE

Juan Castro, FM-35, 202-586-9706
Charles Tiplitz, FM-35, 202-586-3508

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7. RELATED TRAINING

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