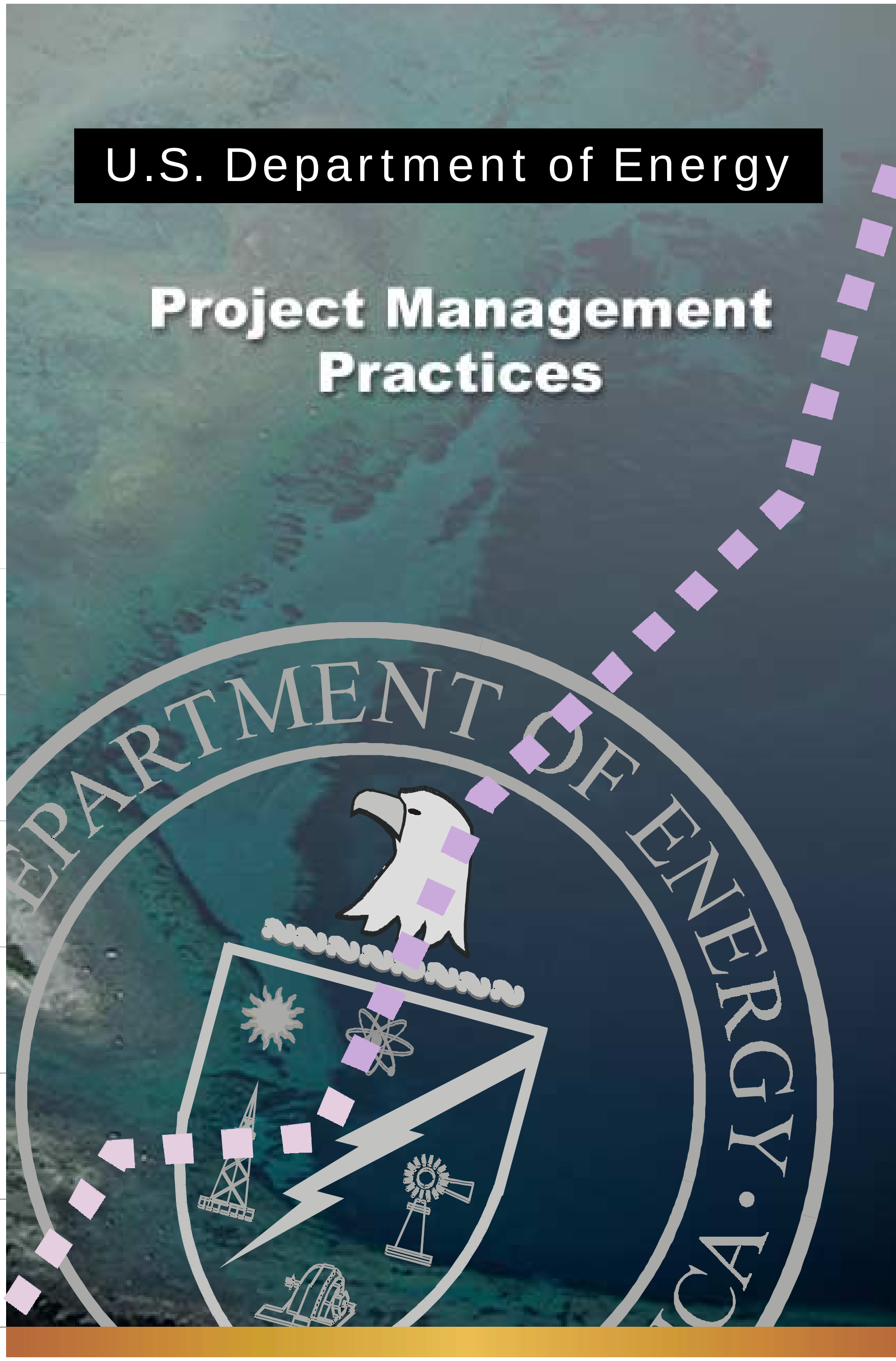
U.S. Department of Energy

Project Management Practices



Project Completion

Project Inception

October 2000

Draft

Table of Contents
Project Management Practices

Practices

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Practice 1

1 Purpose and Overview

1 PURPOSE AND OVERVIEW

Many talents and skills are expected and required of a project manager and the supporting project team. This is because this group of people is expected to successfully manage a project from pre-concept to turnover to the user within established scope, schedule, and budget baselines. In addition, when completed, the project is expected to meet all mission objectives, design requirements, and operating criteria. When viewed realistically, the project manager and the project team have (during the life cycle of a project) managed a major corporation in microcosm. All of the efforts and requirements associated with successfully managing a large corporation are embodied in a project.

DOE Order 413.X and DOE Manual 413.X have been prepared and provided to guide and assist the project manager and project team in successfully completing their project. These documents provide a summary and overview of the policies, procedures, and requirements that must be met for a project to be completed within scope, schedule, and cost baselines.

This Practices document elaborates on the information contained in the Order and the Manual by providing supplementary information that, although not required, is recommended to improve DOE's ability to manage projects.

The Practices cover the entire life cycle of a project, from programming and acquisition, to project organization and execution, to turnover of the completed project (deliverables) to the user organization. The Practices provide information in greater detail than the manual, along with supporting information, recommendations, and examples. The Practices also contain a glossary of definitions and acronyms that are consistent with those commonly used in the field of project management.

The acquisition strategy required by DOE O 413.X is not like the acquisition plan required by Federal Acquisition Regulation (FAR), Part 7. The acquisition strategy is a top-level description that is sufficient for the decision-makers who report to the Secretarial Acquisition Executive to assess if the strategy makes good business sense, and effectively implements laws, and policies and reflects the priorities of top management. Once approved by the SAE, the acquisition strategy provides a basis for more detailed planning. This type of acquisition strategy is unique to major systems acquisitions.

In a broader context, FAR requires acquisition planning for all procurements, and the FAR requires program managers to perform acquisition planning for all acquisitions. Written acquisition plans should be prepared for acquisitions that exceed $1 million. Acquisitions plans are execution-oriented and tend to contain more detail than an acquisition strategy.

Practice 2

Acquisition Strategy and Plan

2 ACQUISITION STRATEGY AND ACQUISITION PLANNING

2.1 OVERVIEW

The acquisition process is of such importance to DOE projects that a basic Acquisition Strategy must be developed and then be continuously reviewed to ensure that it is both being properly implemented and that it always reflects current project needs. Initially the strategy is a top-level description of proposed project activities required to produce a system or project. There should be sufficient detail to enable Department decision-makers reporting to the SAE to assess whether it makes good business sense, effectively implements laws and policies and reflects the Governments priorities. The strategy, which subsequently be reflected in an Acquisition Plan, is required for all projects; however, its complexity and content will be tailored to the project's size and technical requirements. In the case of smaller and less technically demanding projects it may be sufficient to combine the strategy and plan requirements in a single document.

Once the strategy has been approved it will become the basis for the Acquisition Plan which contains the more detailed procurement strategies and supporting assumptions by which a system, project or product is obtained by the Government. An Acquisition Plan is required for all acquisitions greater than $1M. The Plan is initially prepared in advance of the Project Execution Plan (PEP) but may subsequently become included as a key element of the PEP. As acquisition planning matures through the project's phases the acquisition strategy is reviewed and periodically updated.

Development of the acquisition strategy and the preparation of the Acquisition Plan begins as soon as practicable after the system/project is identified and in preliminary form, is part of the Mission Need Decision (CD-0) documentation. Since this will generally be well in advance of the fiscal year in which contracts are expected to be awarded the content of the Plan must be treated with a degree of sensitivity. An updated plan is provided at subsequent Critical Decisions either independently or as an integral part of the PEP. The Plan, after approvals, becomes the guidance document for future contracting and procurement actions.

2.2 Responsibilities and Approvals

The Strategy or the combined document provides input for the Mission Need decision; however, for major systems the strategy may have already been pre-viewed by the PSO and AE to pave the way for the subsequent decision. As soon as the project has received Mission Need approval and cognizant personnel are assigned, including the HQ Program Manager, Federal Project Manager and the nucleus of the IPT, the Plan is more fully developed. Drawing on the definition of the project developed during conceptual design the IPT expands the Plan to the point that it is complete to the extent possible based on the information available. The Plan is signed off by the IPT (which must include Contracts participation) and is included in the Preliminary Baseline Range Approval (CD-1) package. This approval is also the SAE/PSO approval of the Plan and it becomes direction to the Field Contracting Officer to implement as appropriate.

The Plan will be maintained current by the IPT and subsequent approvals will normally be performed as part of the PEP approvals. However; when significant changes to the Acquisition Strategy effecting the Plan occur between CD cycles, the revision will be concurred in by the IPT and submitted to the cognizant Change Control authority for approval prior to implementation. Adequate lead times must be provided for approval turnarounds to allow for the initiation of proposal and bid packages.

2.3 Acquisition Strategy

The Acquisition Strategy establishes the framework within which later detailed planning and execution are accomplished. The Strategy describes at the summary level, the process through which the government will acquire capital assets and is required for all major systems. The Strategy process may also be applied to Other Line Item Projects if technical or other factors indicate the early, top-level visibility is warranted. The establishment of the Acquisition Strategy is a responsibility of the Federal government. The unique aspect of the Strategy, that sets it apart from the Acquisition Plan, is its orientation toward the relationship of essential program elements including management, technical requirements, resources, testing, safety, procurement, third party interests, etc. The strategy is to select from the many possibilities, the approach which will best serve the project, Government and ultimately the taxpayer. After approval the Strategy may become an integral part of, and is the basis for, the Acquisition Plan which in turn may become an element within the PEP. The IPT with concurrence of the SAE/AE will determine the sequencing of the documents in the best interests of the project.

2.4 Acquisition Plan

The Acquisition Plan delineates in ever increasing detail the processes by which the Government and/or its contractors will acquire a system, project or product or portions of such systems. These include many factors and contracting or procurement strategies which must be tailored to the requirements of the procurement including technical capability, cost and schedule for delivery.

The Plan provides a description of the means by which the projects contracting and procurement will be carried out and helps ensure consistency and timeliness in the preparation of contractual execution documents. The Plan then spells out the item to be procured, e.g. A&E services, and the best method for procuring such services. In terms of the service, it may be fixed price or some form of incentive award contract; it may be competitively bid or be a captive contractor already in place. In addition and depending again on a variety of conditions, this contractor may in turn provide contracting services for the Government. It is common practice for the A&E to become the contracting authority for construction and inspection services. Likewise it has been common practice for the M&O/M&I contractor to procure technical or operating equipment since they often possess the skills to make such procurements. Each project's Acquisition Plan specifies the performing organization, DOE or contractor, identified in the Strategy to execute the procurement activity.

The Acquisition Plan outlines the requirement and the recommended solutions as well as the alternatives. This may be very preliminary at the time of CD-0 but will be expanded as the project itself is better defined in Conceptual Design. As this definition matures, so does the strategy which then may be folded into the Acquisition Plan which will be submitted for approval at CD-1 and will be the vehicle for initial contracting actions. If separate Acquisition Strategy and Acquisition Plans are prepared, the acquisitions may not be approved until the Acquisition Strategy has been approved the by the Critical Decision authority.

An Acquisition Plan prepared in accordance with Federal Acquisition Regulations (FAR) is required for every project contract or system of project contracting that will be accomplished by direct DOE placement. For contracts that will be placed by the M&O/M&I contractors, the DOE Contracting Officer shall insure that the contractor's procurement system requires a written acquisition plan that is tailored to the requirements and value of the award.

The Acquisition Plan and/or parent PEP will be maintained current throughout the life of the project and will be updated as necessary, usually in support of a CD; however, if intermediate changes are of significant magnitude, the revision may be processed through the Change Control authority after signoff by the IPT.

ELEMENTS OF AN ACQUISITION STRATEGY

The following is a sample format for the development of an Acquisition Strategy:

I. Requirement

- A. Summary Description
- B. Identification of authoritative source documents (e.g., Operational Require ments document (ORD), Acquisition Program Baseline (APB) *
- C. Status of requirement definition (e.g. not yet complete; complete and current; being revised, etc.)

II. Program Structure

- A. Summary Diagram
- B. Acquisition Phase
  1. For Each Phase:
     - a. Name
     - b. What is to be Accomplished
       - 1) Exit Criteria
       - 2) Maturity of system design and system specification at end of phase
       - 3) Other Products of Phase
     - c. Critical Events (e.g., design reviews; tests)
  2. Concurrency

III. Risk Assessment

IV. Approach to Managing Program/Project Cost and Performance
- A. Establishing Cost Objectives
- B. Managing Tradeoffs between Cost and Performance
  1. Anticipated Evolution of trade space
  2. How tradeoffs will be encouraged
  3. Government role in Managing or approving Tradeoffs

V. Program Management

- A. General Philosophy and Approach
- B. Responsibilities
- C. Resources
  1. Funding
  2. Staffing
     - a Government
     - b Contractor support
- D. Internal Controls
- E. Tailoring and Streamlining Plans
  1. Requests for relief or exemption from requirements
  2. Other tailoring or Streamlining Plans

VI. Business and Contracting Strategy

- A. Industry Involvement in the Program/Project to Date
- B. Competition
  1. Market Research Conducted and/or Planned
  2. Potential Sources
  3. Plans for Full and Open Competition
- C. Contracting Strategy
  1. Major Contract(s) Planned
  2. Contract Structure
     - a. Basic Contract (what it buys; how major deliverable items are defined)
     - b Options if any
  3. Contract Type
     - a Basis for selection (in terms of FAR Part 16)
     - b Linkage to program risk assessment

4. Incentives
   a. Cost Control
   b. Meeting or exceeding program cost objectives
   c. Performance
   d. Other
5. Special Contract Terms and Conditions

D. Component Breakout

VII. Other Important Considerations

ELEMENTS OF ACQUISITION PLAN

The following is a sample format for the development of an Acquisition Plan. For smaller projects and products a tailored approach is used to provide only that information necessary for useful management.

I. ACQUISITION BACKGROUND AND OBJECTIVES

A. Program Description
   1. Program Authority and Identification
   2. Statement of Need
   3. Background
   4. Acquisition Alternatives
   5. Milestone Chart Depicting the Objectives of the Acquisition
   6. Milestones for Updating the Acquisition Plan

B. Applicable conditions

C. Cost
   1. Life Cycle Cost
   2. Design-to-cost
   3. Application of Should Cost
   4. Contract Pricing

D. Capability or Performance

E. Delivery or Performance Period Requirements

F. Trade Offs

G. Risks

H. Acquisition Streamlining

II. Plan of Action

A. Sources
B. Competition
   1. Competition, Component Breakout
   2. Competition, Spares and Repair Parts
   3. Competition, Subcontracts
   4. Multiple Sourcing
C. Source Selection Procedures
D. Contracting Considerations
   1. Contract Type
   2. Warranties
   3. Contract Administration/management
E. Budgeting and Funding
   1. Program Funding
   2. Contract Funding
F. Product Descriptions
G. Priorities, Allocations and Allotments
H. Contractor Versus Government Performance
I. Inherently Governmental Functions
J. Management Information Requirements
K. Make or Buy
L. Test and Evaluation
M. Logistics Considerations
   1. Assumptions Concerning Contractor or Agency Support
   2. Quality Assurance, Reliability and Maintainability Warranties
   3. Requirements for Contractor Data
   4. Standardization Concepts
   5. Continuous Acquisition and Life cycle and support (CALS)
N. Government Furnished Property
O. Government Furnished Information
P. Environmental Considerations
Q. Security Considerations
R. Other considerations
S. Milestone for the Acquisition cycle
T. Identification of Participants in Acquisition Plan Preparation

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Practice 3

3

Integrating Safety and Quality in Projects

3 INTEGRATING SAFETY AND QUALITY IN PROJECTS

3.1 OVERVIEW

The basic approach to project management is to begin the project with the product clearly in mind. This approach includes preparing, early in the project, to consider and identify at least minimal safety, health, environmental, and quality concerns.

3.2 INTEGRATED SAFETY MANAGEMENT

An Integrated Safety Management System (ISMS) is an overall management system designed to ensure that environmental protection and worker and public safety are appropriately addressed in the performance of any task. The fundamental premise of Integrated Safety Management (ISM) is that accidents are preventable through early and close attention to safety, design, and operation, with substantial stakeholder involvement with the teams that plan and execute the project, based on appropriate standards. The safety management system consists of (1) the objective, (2) the guiding principles, (3) the core functions, (4) the mechanisms of implementation, (5) clear responsibilities for implementation, and (6) implementation. As such, an ISMS is characterized by a management system's ability to implement the five core management functions and seven guiding principles using the key implementing factors.

Although safety is a line management function, all members of the Integrated Project Team (IPT) need to maintain a safety focus. In the design stages of a project it is most critical that a safety-through-design approach be embraced. A facility that meets the requirements is not necessarily the safest facility. As will be discussed in the following sections, a safety-through-design approach often permits radical solutions to providing safety that can lead to hazard elimination or reduction by modifications in the process approach or design approach. As noted in Section 3 of the manual, this approach makes use of the familiar ISM principles and functions to address design as well as performing physical work.

3.2.1 Summary

Section 3 of the manual provides the overall description of ISMS and its integration into the project requirements and programs. This Practice will focus on the specifics of implementation at each project stage and the documents that are applicable for that stage. It has been developed with a focus on high-hazard, complex nuclear facilities. Risk based tailoring of the guidance provided within these Practices should include project, public, worker and environmental risks. An ISMS provides an appropriate and effective umbrella for cost-effective implementation of many related DOE programs. For example, safety, health, environmental, and quality issues are best implemented via ISM. The ISMS would not perform its function however as a standalone activity. Therefore, to integrate these principles and functions into the project, they are best defined and implemented via the Project Execution Plan. By integrating ISM into the Project Execution Plan, the implementation of these programs becomes integrated into the project rather than being viewed as a standalone program.

To implement ISM, the project needs to have a commitment to a standards-based safety program. Therefore, the S/RID or work smart standards processes should be an integral part of the first element (Define the Scope of Work) of ISM. As discussed later, the elements of other safety programs, such as Voluntary Protection Program (VPP) and Enhanced Work Planning (EWP), can also be described in terms of the ISM core functions and integrated into the project practices. If the project chooses to implement environmental management via ISO 14001, then the environmental management system elements of ISO 14001 can also be described and implemented through ISM. Environmental management cycle implementation is described in Section 3.4 of this Practice.

A successful ISMS can demonstrate that the implementing documentation and procedures appropriately address the ISMS principles and core functions. A crosswalk of project documentation covering ISM core functions and principles (Figure 3-1) provides a useful tool in both evaluating required project documentation and critical content for specific documents.

3.2.2 ISMS Description

The expectations for an integrated safety management approach can be described by a successive set of actions or activities. This management system is modeled by the five core safety management functions:

	Line Management Responsibility for Safety	Clear Roles and Responsibilities	Competence Commensurate with Responsibilities	Balanced Priorities	Identification of Safety Standards and Requirements	Hazard Controls Tailored to Work Being Performed	Operations Authorization
Baseline Scope of Work	CDR	CDR, QAP,PCS	QAPP	PCS, RP	CDR	SIP	PEP, PCS
Analyze Potential Hazards	CDR, SEMP, DEP	SIP, RMP PEP	QAPP, SEMP, DEP	CTP, SIP, RMP, SIP	CDR, SIP	SIP	PEP
Develop Design Controls	CMP, SEMP, DEP, ECP	QAPP, PEP, SEMP, DEP, ECP	QAPP	SIP, ECP, SEMP, DEP	SIP, ECP, QAPP	SIP, ECP	OMP, ECP
Perform Work/Design (Planning)	CMP, PMP	QAF SEM					P,
Review, Feedbk, Improvement & Validation	QAPP, SEMP	QAPP	QAPP	CDR-Trade Studies, SEMP	QAPP, SEMP	QAPP	RMP, PMP

Project Programs and Procedures are Mapped to ISM Design Phase Principles and Core Functions.

Nomenclature

Project Execution Plan (PEP)
Project Control System (PCS)
Environmental Compliance Plan (ECP)
Risk Management Plan (RMP)
Design Execution Plan (DEP)
EResource Plan (RP)

Core Technology Plan (CTP)
Safety Implementation Plan (SIP)
Systems Engineering Management Plan (SEMP)
Quality Assurance Program Plan (QAPP)
Project Management Plan (PMP)

Figure 3-1 Typical Crosswalk of ISMS Design Phase Principles and Core Functions

- Define the work scope and how it is to be prioritized and accomplished.
- Identify and analyze the hazards associated with the work or eventual use of the design.
- Develop the controls (including requirements) tailored to the work and hazards.
- Perform the work as authorized, following confirmation of readiness.
- Assess the effectiveness of the system and feedback results to improve the process or design.

The five core ISMS functions are usually depicted graphically as shown in Figure 3-2. Although arrows indicate a general direction, these are not independent, sequential functions. They are a linked, interdependent collection of activities that may occur simultaneously. Outcomes during the accomplishment of one function may affect other functions and potentially the entire system. These functions are not a one-time process for a project, but are normally repeated many times during the project life cycle because the work product at various project stages may vary

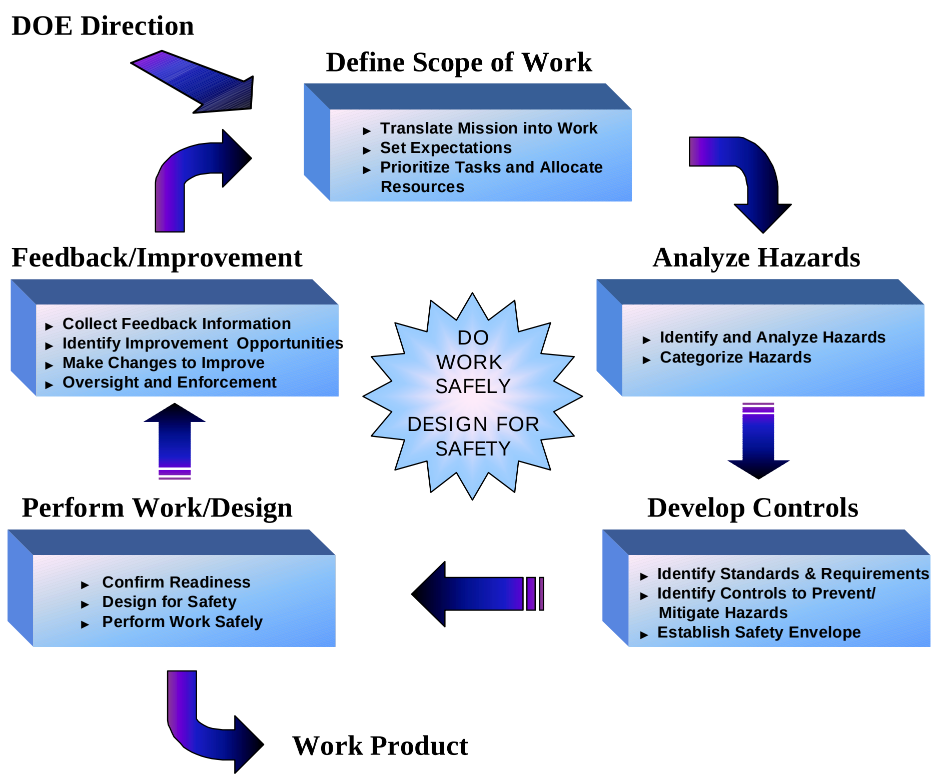


Figure 3-2. ISMS Functions

significantly. Addressing ISMS issues early permits a design-through-safety approach within the project. Thus, safety, health, environmental, and quality issues can be cost-effectively implemented in the design. Safety-through-design is not just meeting the specified safety requirements in the design. It is the project team taking specific actions regarding safety, and includes making design changes to: eliminate hazards, minimize hazards, mitigate consequences, and preclude the events that could release the hazard. Addressing hazards with a safety-through-design approach does not require that systems, structures, or components be added that will prevent or mitigate the releases. It involves removing or moving systems or adopting design approaches that result in a safer facility and improved operations, and often results in lower safety class and less safety significant controls being required in the final design.

For the simplest projects, the five core functions can be implemented in order. However, in projects involving a new design or significant modification, evolving design, or R&D, the project proceeds through the five core functions both at the project level and task level many times throughout the project life cycle. This relationship is presented graphically in Figure 3-3.

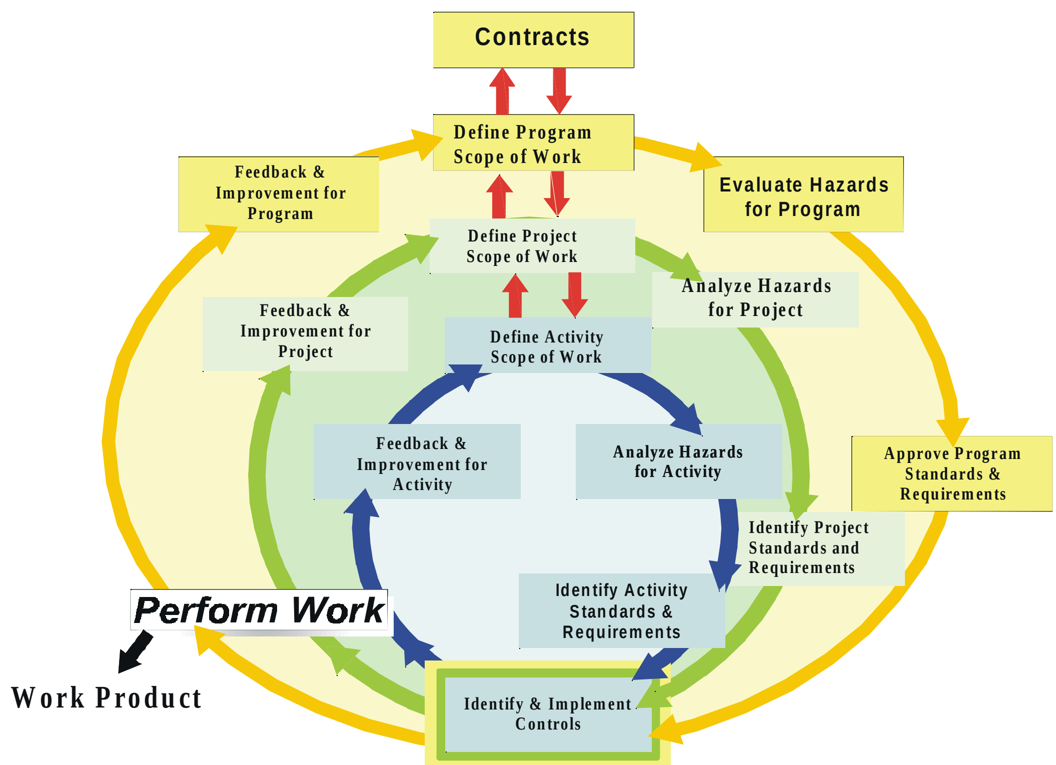


Figure 3-3. Relationship of ISMS Core Functions and Program, Project and Activity

This section addresses the specific implementation of the core functions as they relate to design, and provides an overview. The following sections provide input relative to the ISMS functions in the conceptual (3.2.3), preliminary (3.2.4), final design phase (3.2.5), and construction, startup/turnover phase (3.2.6).

The ISM core functions require further explanation to understand the implementation in each phase of the project. Figure 3-4 shows each of the five core functions and a generic description of their implementation in a project environment. This depiction is presented to help understand the concepts associated with each core function and the interrelationships with project activities. There is no intention to imply that the functions be completed as specific time-phased steps in a design stage. As described in Section 3.3, typically, the cycle through the five core functions is completed many times within each design phase and at multiple levels within the project. It is only important that the activities of each function be completed and the results support the required tasks associated with successive functions.

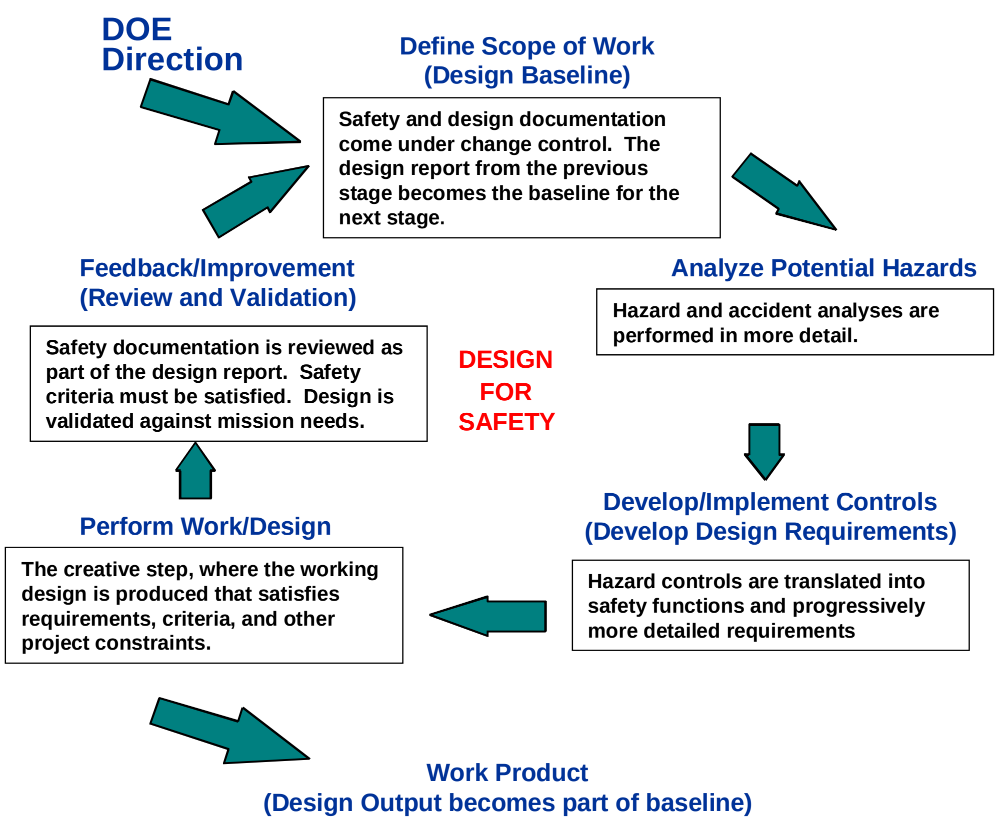


Figure 3-4. Safety Aspects in a Typical Design Stage

It is important to note that the IPT may quickly move through each of the core functions many times in developing the conceptual design. The proper time to identify requirements, hazards, controls, potential solutions and the acceptability of the integrated set is early in the project life cycle. By approaching the design with a safety-through-design approach, the basic approach can be tested and the most appropriate solution defined. This may include challenging the reference design with innovative design solutions that change the basic processes to achieve a safe facility rather than just add controls to achieve safety. This approach of just changing the parameters to optimize the design has been used successfully by many projects to provide a significantly safer facility.

Baseline Scope of Work: During each design stage, the project documentation progressively develops more detailed requirements and project definition. The project requirements baseline and technical baseline form the basis for entering into the next project phase. This step creates the design baseline. It is important, early in the project, to evaluate the feedback provided in the fifth core function to determine the adequacy of the requirements and scope statement provided in this first core function. As the project moves to later stages of the design, then changes to the requirements and scope of work become more costly and need to be considered carefully as to whether the change is warranted.

Analyze Potential Hazards: Hazards and accidents are evaluated in progressively more detail as the design progresses from design stage to design stage. Although formal documentation of certain hazard analysis is not required until much later in the project, preliminary hazards and accident analysis should be initiated early to guide or drive design decisions and design requirements. It is important to identify the hazards and the potential release mechanisms associated with the hazards. This step provides guidance to those that develop controls and designs to safely handle the controls. This information can also be useful in providing feedback to the project as to the potential of eliminating or minimizing the hazard with reference design changes. The earlier in the project life cycle that these types of changes can occur, the more cost-effective the change.

Develop Design Controls/Requirements: The results of the hazard analysis and accident analysis provide input to the selection of applicable controls to assure that the facility meets all safety requirements. This element establishes requirements on the design that eliminates the hazard through design, minimizes the potential for events that could cause an uncontrolled release of the hazard, or provides controls that mitigate the consequences of an event that releases the hazard. Although project constraints, including applicable laws, rules, codes, and standards, are established for the overall project in the Define Scope of Work step, the detailed implementation and specific application of a law, rule, code, or standard is defined in this step.

Note that in addition to identifying physical and administrative controls, which will provide protection in the facility, the project needs to establish appropriate administrative design process controls to assure that: potential hazards have been addressed, appropriate stakeholders have provided input, the controls are adequate to provide the required function, and appropriate approvals have been provided to proceed to the next design step. These controls are established to provide the designer with the project requirements associated with seeking approval to continue within the Perform Work/Design element. The approval process is provided in the Feedback/Improvement element.

Perform Work/Design: This element is the creative function of the process where the architect/engineer produce a working design that will satisfy requirements, criteria, and other constraints from the previous element. The working design is assembled in project technical baseline documentation. These include documents such as the Facility Design Description and System Design Descriptions. These documents form the upper tier of the project's technical baseline and are therefore placed under configuration control. Specificity is added to these documents within each successive design phase.

Providing a design that meets the requirements and implements the controls identified in the previous function does not guarantee the best solution to providing a safe facility. The design process should adopt a safety-through-design approach to truly integrate safety into the design process. With designers participating on the IPT and in each of the previous functions, they are better able to understand the basis for the design requirements they are given. Additionally, this knowledge permits truly creative and innovative solutions to eliminating or mitigating hazards. The design team can therefore use the feedback core function to recommend changes that can lead to a more cost-effective solution to providing a safe facility.

Review, Feedback, Improvement and Validation: This element provides the review, feedback, improvement, and validation elements for the design. In general this function consists of both the scheduled and unscheduled design reviews. It includes top tier reviews such as the critical decisions, Safety Analysis Reports (PSAR, FSAR), and formal, independent project reviews. It also includes such lower-tier reviews as peer technical reviews of analysis and design, and early analysis feedback on design adequacy to meet identified safety requirements/ controls. The review criteria and results from earlier stages are reexamined in each successive stage to ensure corrective actions from prior reviews have been taken and that changes have not invalidated results from earlier reviews.

3.2.3 Conceptual Design Stage Implementation

Figure 3-5 depicts the relationship between the ISM functions at the conceptual design stage of the project.

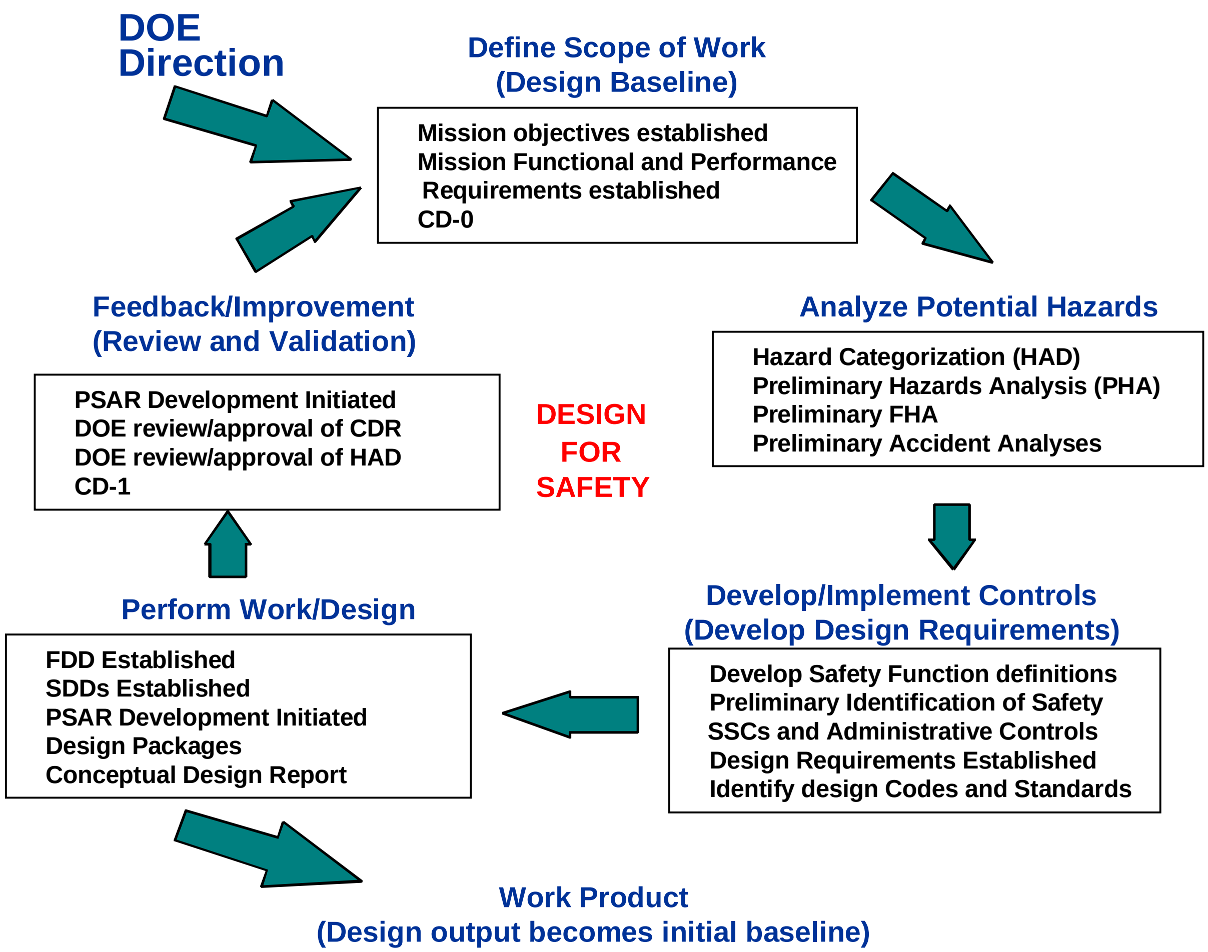


Figure 3-5. Conceptual Design Stage

Baseline Scope of Work:

Mission objectives are established. Once Critical Decision 0 is made, mission functional and performance requirements that will fulfill mission objectives are defined. These requirements form the definition of the design work to be performed during the conceptual design stage. It is imperative that the scope be defined enough to control the project, yet not over specify the design such that innovative solutions to providing safety are precluded.

Analyze Potential Hazards:

The requirements and guidance in this section supplements those in DOE O 420.1 and DOE G 420.1-1. Those two documents provide DOE's primary direction for the safety of nuclear facility design and modification.

For new nuclear facilities, a preliminary assessment of facility hazards is conducted based on a radiological inventory in accordance with DOE-STD-1027-92. For modifications to existing facilities, a similar determination based on inventory and process changes is needed. The results of this assessment are used to determine the initial hazard categorization for the facility and the level and type of safety documentation that will be required for the facility.

Building on the information collected during the initial hazard categorization and using the guidance on graded approach in DOE-STD-1027 and DOE-STD-3009, a Preliminary Hazards Analysis (PHA) is performed based upon envisioned inventories and processes. For hazard category 1 or 2 facilities, unmitigated accident scenarios are used to see if Safety Class structures, systems, and components are needed. Also, an initial set of Design Basis Accidents (DBAs) are identified for Category 1 and 2 facilities.

After the PHA is performed, the "final hazard categorization" is determined using the guidance in DOE-STD-1027. This categorization should be revisited periodically as the design evolves to ensure that the hazard category identified is still appropriate. It may be useful to determine whether certain design alternatives would result in the facility being in a different hazard category. If so, this could be a factor considered in the selection of design alternatives. Requirements for safety analysis and documentation are graded partly based upon the hazard categorization, using the guidance in DOE-STD-1027 and DOE-STD-3009.

A preliminary Fire Hazards Analysis (FHA) is performed for inclusion in the Conceptual Design Report to assure that appropriate attention has been paid to separation of structures, systems, and components and life safety egress considerations. In addition, early development of inputs the PSAR are initiated in this stage. It should be noted that within the ISM functions, the development of the PSAR serves several functions. The analysis required to develop the PSAR provides the information critical to the hazard analysis and the types of controls that are required to assure that the environment, public, and workers are adequately protected. It is a critical element of the Analyze Hazards step. Secondly, the analysis required to develop the PSAR may be used to select appropriate controls. Finally, it provides critical and timely feedback to designers regarding functions, design requirements, and acceptability of proposed design solutions.

Develop Design Controls/Requirements:

According to the requirements in DOE O 420.1 and the guidance in DOE G 420.1-1, decisions are made to reduce, prevent, or mitigate hazards. Alternative approaches should be considered and, if promising, carried further into the design process. As noted earlier in this section, the evaluation of alternatives should include not only alternative engineering controls, but innovative solutions that may eliminate or significantly reduce the hazard.

When prevention or mitigation is chosen, the preventive or mitigative functions required are developed into safety function definitions. Define programs guidance for safety function definition can be found in DP SIL 96-04. The ideal approach is to formulate the safety function definition independently and then, using the IPT and all appropriate stakeholders, identify or propose one or more structures, systems, and components that could best fulfill the function. During the conceptual stage, alternative design solutions should be identified and developed so that the optimal facility configuration can be chosen at CD-1. By involving applicable stakeholders in the selection of controls, the optimal facility configuration is developed as a part of the process and not as a stepping stone in the project lifecycle.

The end-product of this function is a preliminary identification of the structures, systems, and components that will be required to fulfill safety functions for the new or modified facility. In addition, alternative approaches are not only identified, but developed sufficiently to present as viable alternatives for CD-1. This important change to the way most DOE projects have been conducted in the past enables facility features and systems to be conceived and designed with safety-based requirements included and optimized, rather than added on later with attendant additional cost and decreased effectiveness.

During the conceptual design stage, safety function definitions are expanded and, using the hazard analysis results, developed into a general set of design requirements. For this stage, the design requirement parameters need only be developed sufficiently to use as a basis for estimating costs of major design features and components.

An important part of this process is the identification of codes and standards that will apply to the facility and its structures, systems, and components. During the conceptual design stage, the broadest identification includes laws, rules, regulations, DOE Orders, and DOE Guides; as well as building codes and industry standards having general applicability to the work to be performed.

Perform Work/Design:

Design output drawings for this stage should include facility layout and elevation drawings. Functional diagrams of important facility systems, including safety systems, should show system boundaries, major subsystems and components, interfaces to supported or supporting systems, and interfaces to other systems.

System Design Descriptions for safety structures, systems, and components are begun. The information described in Chapter 1 of DOE-STD-3024 is produced and placed under configuration control. The information described in Chapter 2 is prepared in draft. The information for the Facility Design Description that meets the intent of DOE-STD-3024 Chapters 1 and 2 is produced and placed under configuration control.

Review, Feedback, Improvement and Validation:

Feedback and Improvement is implemented in several layers within the project at each of the stages. PSAR development provides critical feedback to the project on requirements and acceptability of the proposed design solutions. PSAR development is therefore initiated in the conceptual design stage. In addition, task-level peer reviews, as well as formal project reviews, are implemented at this stage.

The following questions should be answered, if applicable to the project, during the conceptual design review process:

- Does the preliminary hazard analysis follow a methodology appropriate for the type of facility/process, the types of hazards that may be involved, and the level of analysis needed?
- Have all major types of hazards been addressed?
- Have forms and quantities of major hazardous materials been identified?
- Is there appropriate identification of all processes and operations?
- Are the safety function(s) defined in agreement with the define programs guidance in DP SIL 96-04?
- Have safety-class and safety-significant structures and systems been appropriately identified?
- Have design requirements for facility safety been preliminarily apportioned/ assigned to identifiable systems or structures?

- Have the scope and boundaries of every safety system and structure been delineated?
- Have major subsystems and components, that may be associated with or defined as part of a specific safety system or structure, been preliminarily identified?
- Have major interfaces between safety systems and structures, and non-safety systems and structures, been preliminarily identified?
- Are major support and supporting systems preliminarily identified?
- Have political, strategic, and legal constraints on the safety design of the facility been identified?

3.2.4 Preliminary Design Stage Implementation

Figure 3-6 depicts the relationship between the ISM functions at the Preliminary Design stage of the project.

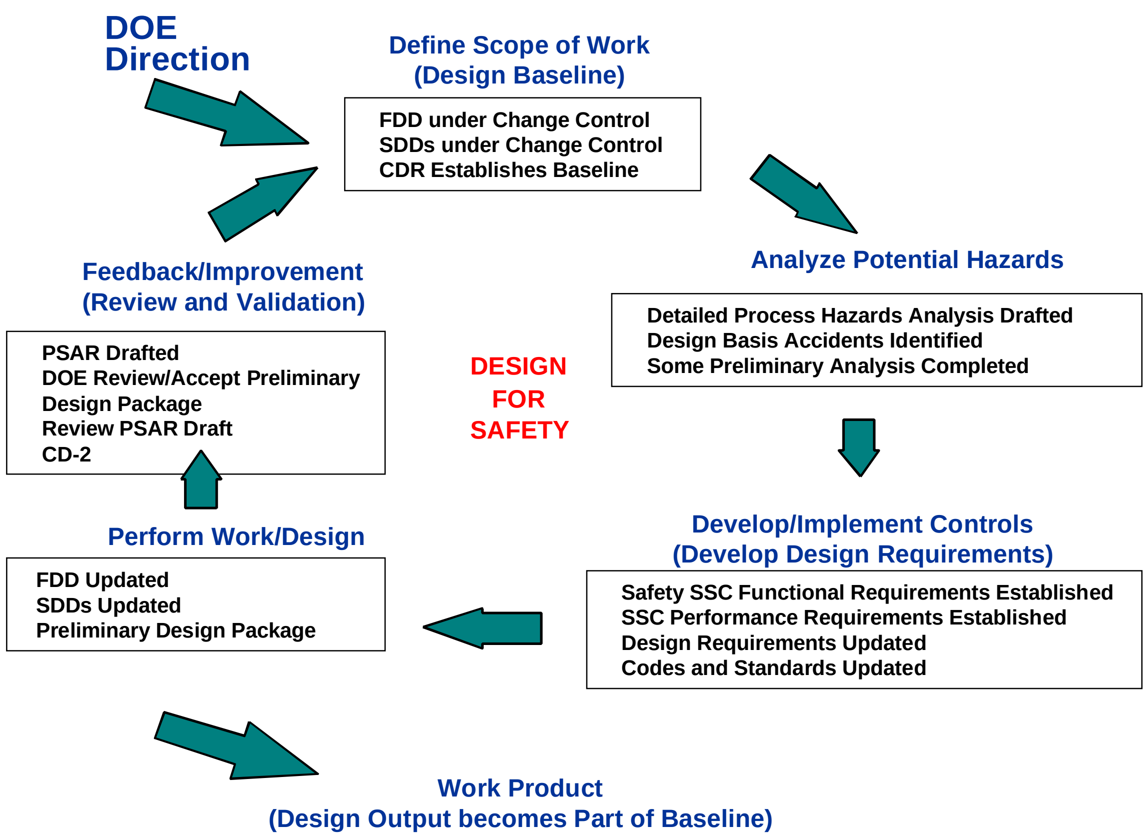


Figure 3-6. Preliminary Design Stage

Baseline Scope of Work:

The results of the Conceptual Design Report review establish the design baseline at the facility level and serve as the definition of technical work to be performed in the preliminary design stage. Those parts of the FDD and SDDs completed during the prior stage are placed under configuration control. Additional project constraints may be placed on the project based on the approval of the Conceptual Design Report. These constraints are included in project documentation.

Analyze Potential Hazards:

The results of the preliminary hazards analysis and the facility and process design from the previous stage are used as a basis for a more detailed process hazards analysis. Guidance for this analysis is provided in DOE-STD-1027 and DOE-STD-3009. Previous decisions on whether to reduce, prevent, or mitigate hazards are reviewed and modified as indicated.

For Category 1 and 2 facilities, the set of DBAs is finalized. DBAs are postulated accidents that the facility is designed to withstand. DBAs should be used to determine needed safety functions for safety structures, systems, and components. DBAs for a new facility are expected to result in negligible offsite consequences since the facility is designed to handle them.

Develop Design Controls/Requirements:

Alternative approaches that were identified during conceptual design are down-selected to the one (or, at the most, two) most promising to be continued in the design process. Safety systems are specifically identified and finalized following this down-selection. Safety function definitions from the previous stage are refined, if necessary, to reflect this increased specificity.

Design requirements for structures, systems, and components are updated to include functional requirements, specific parameters for performance, and the range of environmental conditions over which the structures, systems, and components is expected to fulfill its function. These requirements should fully support the fulfillment of identified safety functions.

The identification of laws, rules, regulations, DOE Orders, and DOE Guides; as well as building codes and industry standards that are applicable to the work to be performed; is taken to the next level by extracting (but preserving reference information) specific requirements that individual structures, systems, and components will comply with. Requirements that would be considered mandatory, but that will not be complied with, are also identified, and the basis for the noncompliance provided so that requests for exemptions or waivers can be prepared.

Perform Work/Design:

DOE O 420.1 provides the Department's requirements for the safe design of nonreactor nuclear facilities. DOE O 5480.30 provides the Department's requirements for the safe design of nuclear reactors.

The information described in chapter 2 of DOE-STD-3024 for SDDs is completed. The information for the Facility Design Description that meets the intent of DOE-STD-3024 Chapters 1 through 3 is completed.

Design output drawings for this stage should include system and facility layout and elevation drawings that indicate materials of construction. Also included are one-line diagrams for electrical systems, flow diagrams for ventilation systems, logic diagrams, and similar diagrams for other types of systems. Functional diagrams of important facility systems, including safety systems, should delineate system boundaries, show all subsystems and components, show interfaces to supported or supporting systems in detail, and show interfaces to other systems in detail.

Review, Feedback, Improvement, and Validation:

Review, feedback, improvement, and validation are implemented in several layers within the project at each of the stages. The PSAR development provides critical feedback to the project on requirements and acceptability of the proposed design solutions. The PSAR also provides a part of the basis for CD-2. A draft PSAR is therefore completed in the Preliminary Design stage. In addition, task-level peer reviews, as well as formal project reviews, are performed at this stage.

The following questions should be answered, if applicable to the project, during the Preliminary Design Review process:

- Does the hazard analysis (HA) process follow the guidance in DOE-STD-1027 and Chapter 3 of DOE-STD-3009-94?
- Is a recognized HA methodology used? For example, a methodology recommended in "Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples" from the Center for Chemical Process Safety.
- Is the methodology used appropriate for the type of facility/process, the types of hazards, and the level of analysis needed?
- Have all applicable types of hazards been addressed in the HA?
- Have all applicable release initiators been addressed (e.g., Internal/process, External, Natural Phenomena)?

- Have forms and quantities of all hazardous materials been identified?
- Are all processes and operations identified and clearly described?
- Have DBAs been identified and analyzed, as appropriate?
- Have appropriate safety-class structures and systems been identified?
- Have appropriate safety-significant structures and systems been identified?
- Are safety function(s) defined for each safety structure and system in agreement with the define programs guidance in DP SIL 96-04?
- Have all functions required for facility safety been apportioned/assigned to specific and uniquely identifiable systems or structures?
- Have the scope and boundaries of every safety system and structure been delineated?
- Have subsystems and components been associated with and defined as part of a specific safety system or structure?
- Have interfaces between safety systems and structures and non-safety systems and structures been identified and described?
- Are support and supporting systems identified?
- Are accidents, situations, and/or modes for which a system's or structure's safety function is required identified and linked to the safety analysis?
- Have appropriate sources for criteria-based requirements, specifically including DOE O 5480.30 or DOE O 420.1 and its associated Implementation Guides, been identified?
- Was a reasonable and complete set of criteria selected that encompasses applicable aspects of design and construction at an appropriate level?
- Is the extent and manner in which the selected criteria will be applied defined?
- Has the process by which design requirements will be developed and implemented from the selected criteria been defined?
- Has a set of functional requirements for each safety system and structure been defined?
- Are functional requirements referenced to the safety analysis?
- Do functional requirements support fulfillment of the system or structure's safety function?

- ► Are both active and passive functions identified?
- ► Have normal, abnormal, and accident conditions for which safety system and structures must fulfill their identified safety functions been estimated based on results of the safety analysis?
- ► Are plant or process parameters that need to be monitored as part of the operation of safety systems identified and understood?
- ► Are required plant, process, and system responses that are required as part of the operation of safety systems identified and understood?
- ► Does the decision on whether manual and/or automatic controls are provided reflect the results of safety analysis?

3.2.2.5 Final (Detailed) Design Stage Implementation

Figure 3-7 depicts the relationship between the ISM functions at the Final (Detailed) Design stage of the project.

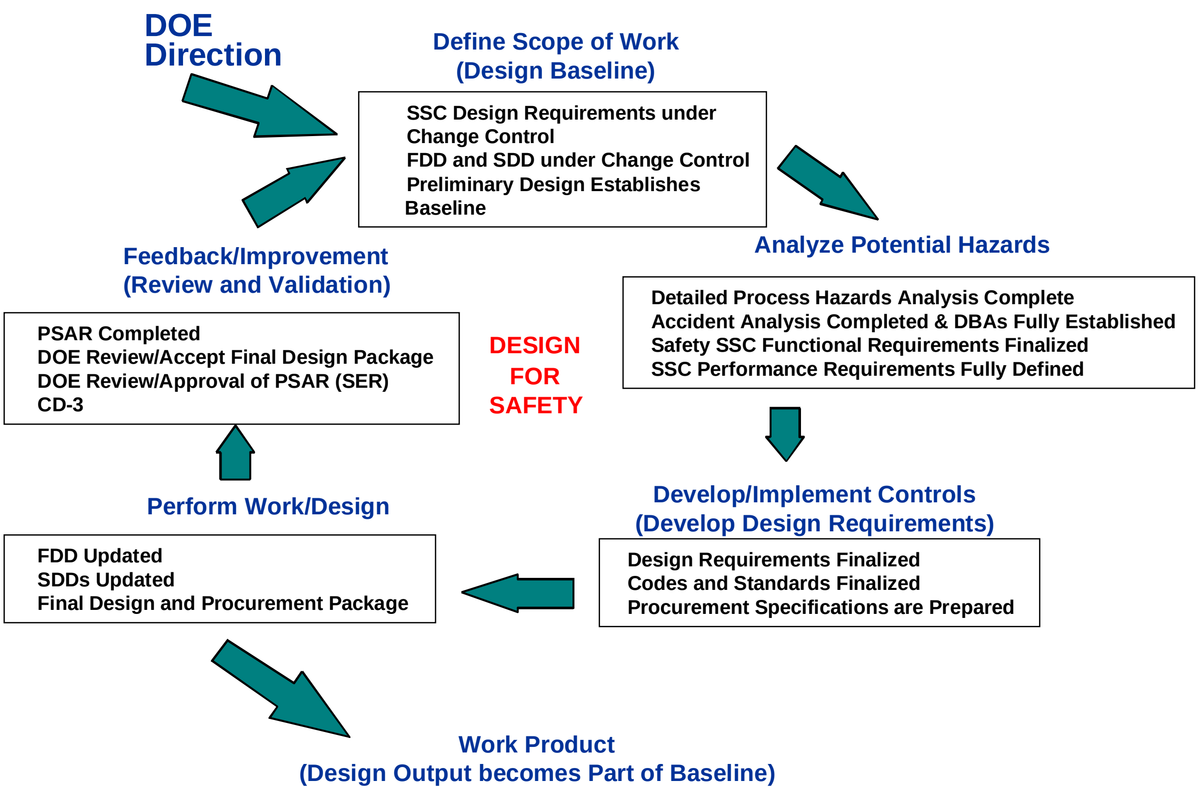


Figure 3-7. Preliminary Design Stage

Baseline Scope of Work:

Preliminary establishes the design baseline at the structure and system level, incorporating the results of the Preliminary Design Review. The design requirements for the facility and its structures, systems, and components are placed under change control. Those parts of the FDD and SDDs completed during the prior stage are placed under configuration control. Based on CD-2, additional constraints may be placed on the project by DOE. These controls should be included in project documentation.

Analyze Potential Hazards:

Before the detailed design of the facility can begin, all design requirements that will be generated from safety considerations should be known. Therefore, all analyses that will appear the PSAR need to be completed early in Final Design. A detailed process hazards analysis, based on the preliminary process design is completed according to DOE-STD-3009. Accident analyses are completed based upon final definitions of design basis accidents. The information described in Chapter 2 of DOE-STD-3024 for SDDs is completed. The information described in Chapter 3 is prepared in draft. The information for the Facility Design Description that meets the intent of DOE-STD-3024 Chapters 1 through 3 is completed.

The hazards and accident analyses provide the basis for finalization of the functional requirements of facility structures, systems, and components. Performance requirements for all structures, systems, and components can then be fully defined. Performance requirements are acceptance criteria or limits against which the actual performance capability of the as-built system will be evaluated.

Develop Design Controls/Requirements:

The information described in Chapter 2 of DOE-STD-3024 for SDDs is completed. The information described in Chapter 3 is prepared in draft. The information for the Facility Design Description that meets the intent of DOE-STD-3024 Chapters 1 through 3 is completed.

The results of the preceding function are combined with other design requirements and specific requirements from codes and standards to finalize the design requirements for structures, systems, and components.

At this point, enough information is known about major systems and components to prepare the technical inputs for procurement specifications. Safety analysts, designers, and purchasing managers work together to ensure that important design features and parameters will appear in procurement documents when they are issued.

Perform Work/Design:

The information described in Chapter 3 of DOE-STD-3024 for SDDs is "finalized" and placed under configuration control. The information for Chapter 4 is prepared in draft, describing systems as the construction, startup/turnover package will portray them. The Facility Design Description is completed and placed under configuration control. The detail design package and Final Design report are prepared.

Review, Feedback, Improvement, and Validation:

Review, feedback, improvement, and validation are implemented in several layers within the project at each of the stages. The PSAR development provides critical feedback to the project on requirements and acceptability of the proposed design solutions. The PSAR provides the basis for the DOE SER and also provides a part of the basis for CD-3. The PSAR is therefore completed in the Final Design stage. In addition, task-level peer reviews, as well as formal project reviews, are performed at this stage.

The following questions should be answered, if applicable to the project, during the Final (Detailed) Design Review process:

- Has a set of appropriate accident types been identified and characterized?
- Have DBAs been identified and analyzed, as appropriate?
- Have criteria-based requirements been refined and successive tiers of referenced criteria been incorporated?
- Are safety structures, systems, and components and their associated support systems designed to standards and quality requirements commensurate with their importance to safety?
- Are the designs of safety systems adequate to fulfill their identified functional requirements?
- Are safety structures, systems, and components designed so the can be expected to perform their safety function reliably under those conditions and events for which their safety function is intended? Is the facility and its systems designed to perform all safety functions with the reliability indicated by the safety analysis?
- Do the designs of safety systems comply with identified criteria-based requirements?
- Are safety structures, systems, and components designed to withstand all design basis loadings, with an appropriate margin of safety?

- Is all equipment selected for application to the specific service conditions based on sound engineering practices and manufacturers' recommendations.
- Does the facility design provide reliable safe conditions and sufficient confinement of hazardous material during and after all DBAs?
- At both the facility and structures, systems, and components level, does the design ensure that more probable modes of failure (e.g., fail to open versus fail to close) will increase the likelihood of a safe condition?
- Are the identified quality assurance provisions commensurate with the structures, systems, and component's importance to safety?

3.2.6 Construction, Startup/Turnover Stage Implementation

Figure 3-8 depicts the relationship between the ISM functions at the Construction, Startup/Turnover stage of the project. As construction, testing, and startup are included in this stage, ISM implementation for physical work (construction, testing, startup, etc.) becomes significant, in addition to the safety-through-design implementation evident in the previous stages.

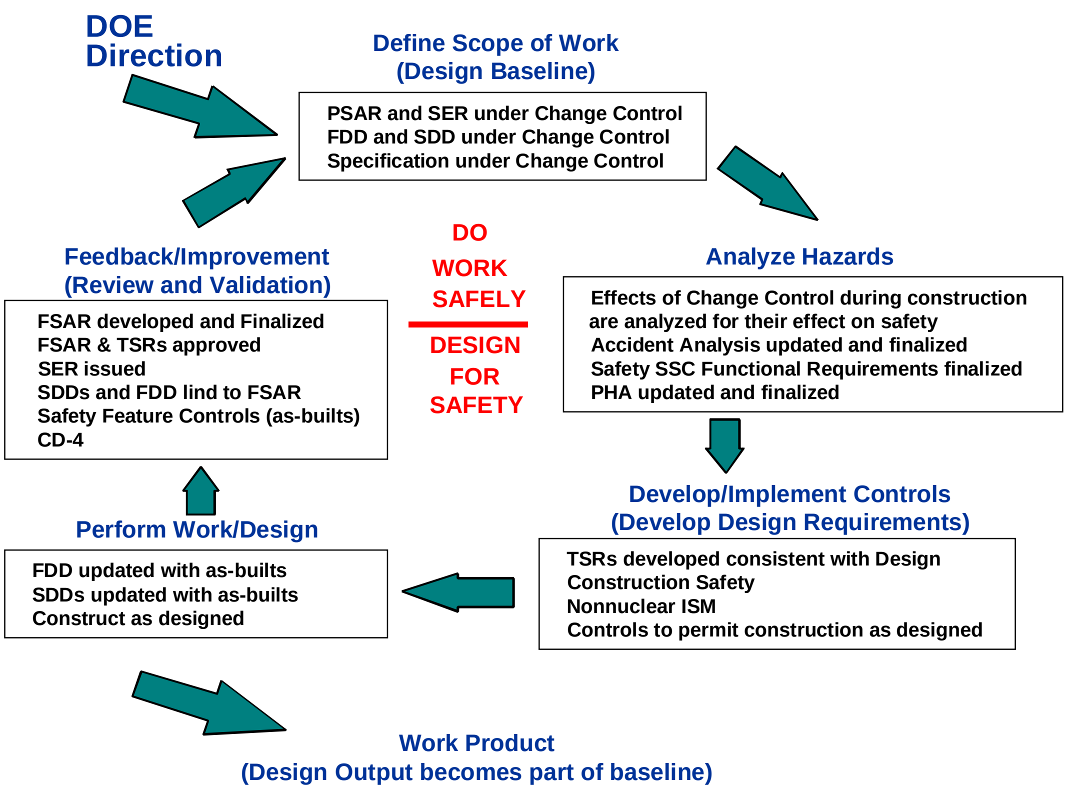


Figure 3-8. Construction, Startup/Turnover

Define Scope of Work:

The design baseline includes construction drawings. The PSAR is approved and its SER written. Both documents are placed under configuration control. The detailed design, including the FDD and SDDs, is placed under configuration control. These documents, and the Final Design Report, define the facility to be constructed during this stage.

Analyze Hazards:

The effects of changes made during construction are analyzed to ascertain their effect on the approved PSAR, and are reviewed and approved at predefined levels. In addition to the potential hazards of facility operation, the hazards associated with construction, testing, and startup must be evaluated.

Develop/Implement Controls:

During construction, component specifications are issued and are used as the technical requirements for procurement of the components and subsystems that will comprise the major structures, systems, and components. Controls associated with construction, testing, and startup must be implemented, based on the hazard analysis.

Perform Work/Design:

SDDs are completed and placed under configuration control. The FDD is updated as indicated and remains under configuration control. Construction, testing, and startup tasks are completed. Once the facility is built, as-built drawings, an approved FSAR, and its SER are required for CD-4.

Review, Feedback, Improvement and Validation:

Review, feedback, improvement, and validation is implemented in several layers within the project at each of the stages. The FSAR development provides critical feedback to the project acceptability of the final design solutions. The FSAR provides the basis for the SER and a part of the basis for CD-4. The FSAR is therefore completed in the Construction, Startup/Turnover stage. In addition, task-level peer reviews, as well as formal project reviews are performed at this stage.

The following questions should be answered, if applicable to the project, during the Construction, Startup/Turnover review process:

- Is the FSAR approved?

- Has the SER been issued?
- Do SDDs and the FDD properly link to and support the FSAR?
- Do as-builts identify safety features?

3.2.7 Summary of ISM Implementation in Design

Figure 3-9 summarizes the ISM design stage expectations for each of the five core functions. By following this approach, and implementing a safety-through-design approach, a project can be accomplished with high confidence that all aspects of safety have been included into facility design. The transition between design and operations should also proceed smoothly since the safety analysis products have been integrated by the IPT with the design and planned operations integrated with the design and reflect the as-built facility. The alignment of the operating procedures and practices, safety documentation, and the physical configuration are maintained in alignment with a working configuration whose physical systems fall with a working configuration management program.

3.2.8 Worker Protection

The primary focus of worker protection during the design phases of a project is: (1) providing a design that limits the hazards for which workers are exposed and (2) providing a design with specific items credited with providing protection for workers, and (3) a robust design based on defense in depth. Traditional worker protection issues handled by integrated safety management are included in all physical facility work practices including construction, testing, inspection, and associated R&D activities. Programs and practices for field work is adequately addressed within both DOE guidance and DOE site practices and will not be address further in this manual. Two examples of these worker protection programs and practices, which are implemented within ISM, are presented in Figure 3-10 for the Voluntary Protection Program (VPP) and in Figure 3-11, Enhanced Work Planning (EWP).

Figure 3-9. Summary of ISM Expectations by Design Stage

ISM Function	Integrated Safety Management Design Steps at each Stage of the Acquisition Sequence			
	Conceptual Design	**Preliminary Design**	**Final Design**	**Construction, Startup/ Turnover**
Define Scope of Work (Design Baseline)	• Mission Objective Established • Mission Functional and Performance Requirements Established • CD-0	• FDD under Change Control • SDD under Change Control • CDR Establishes Design Baseline	• SSC Design Requirements • FDD and SDD under Change Control • Preliminary Design Report Established Design Baseline	• PSAR and SER under Change Control • Detailed Design under Change Control • FDD and SDDs under Change Control
Analyze Potential Hazards	• Hazard Categorization • Preliminary Hazard Analysis • Preliminary Fire Hazards Analysis	• Process Hazards Analysis • Design Basis Accidents Identified	• Detailed Process Hazard Analysis Complete • Accident Analysis Completed and DBAs Fully Established	• Effects of Changes during Construction are Analyzed for their Effect on Safety • PHA Updated and Finalized • Accident Analysis Updated and Finalized
Develop Design Controls/Requirements	• Develop Safety Function Definitions • Preliminary Identification of Safety SSCs • Design Requirements Established • Identify Design Codes and Standards	• Safety Functions Finalized • Identification of Safety SSCs Complete • Safety SSC Functional Requirements Updated • Codes and Standards Updated	• Safety SSC Functional Requirements Finalized • SSC Performance Requirements Fully Defined • Design Requirements Finalized • Codes and Standards Finalized	• TSRs Developed Consistent with Design • Construction Safety Controls Defined and Implemented
Perform Work/Design	• FDD Established • SDDs Established • Conceptual Design Report	• FDD Updated • SDDs Updated • Preliminary Design Package	• Procurement Specifications Prepared • FDD Updated • SDDs Updated • Final Design Package	• Construction Safety following ISM Implementing Program • FDD Completed • SDDs Completed • As-Builts Developed
Review, Feedback, Improvement and Validation	• PSAR Development Initiated • DOE Review/Approval of CDR • CD-1	• Draft PSAR Established • DOE Review/Approval of Preliminary Design Package • CD-2	• PSAR Complete • DOE Review/Approval of Final Design Package • CD-3	• FSAR Developed and Finalized • DOE Review/Approval of FSAR (SER) • FDD, SDDs, As-Builts as Controlled Documents that Control Safety Features • Confirm Readiness to Operate • Transition to Operations • CD-4

Figure 3-10. ISMS Functions Crosswalk with VPP Elements

VPP \ ISMS	Scope of Work	Analyze Hazard	Develop/Implement Controls	Perform Work	Feedback Improvement
Management Leadership	+Annual Operating Plan	+Line Management Responsible for SARs	+Line Management Responsible for TSRs	*Line Management Approvals	*Management Walkdowns *Management Evaluations
Employee Involvement	*Fix it Now Teams *Work Management Centers *Shift Turnovers	*JHA Procedure *Fix it Now Teams *Work Management Centers +PHR	*JHA Procedure *Fix it Now Teams *Work Management Centers	*Stop Work Authority *Fix it Now Teams *Work Management Centers	*Fix it Now Teams *Work Management Centers *Employee Concerns Program *Safety Observers *Critiques *Green Cards
Worksite Analysis		+SAR +PHR *PHA *JHA +USQ			
Hazard Prevention and Control			+TSRs *Lock & Tag *Operating Procedures		
Safety and Health Training	+Annual Operating Plan Training		+S/RID Training	+Conduct of Operations Training	+Expanded Root Cause Analysis Training

Legend: + ISMS only in red; * Both in blue; - VPP only in green; No matches expected in gray areas

Figure 3-11. ISMS Functions Crosswalk with EWP Elements

EWP \ ISMS	Scope of Work	Analyze Hazards	Develop/Implement Controls	Perform Work	Feedback Improvement
Line Management Ownership	*Work Management Centers	*Work Management Centers	*Work Management Centers	*Work Management Centers *Line Management Approvals	*Mgmt Walkdowns *Mgmt Evaluations
Organizationally Diverse Teams	*Fix-it-Now Teams *Work Management Centers	*Work Management Centers +PHR Teams	*Work Management Centers	*Fix-it-Now Teams *Work Management Centers	*Fix-it-Now Teams
Graded Approach	*Fix-it-Now Teams *Work Management Centers	*JHA Procedure *Fix-it-Now Teams *Work Management Centers	*Work Management Centers +Equipment Functional Categorization	*Work Management Centers *Fix-it-Now Teams	Grading provided within programs listed in this column
Worker Involvement	*Fix-it-Now Teams *Work Management Centers *Shift Turnover	*JHA Procedure *Fix-it-Now Teams *Planner Pre-job Walkdowns *Work Management Centers	*JHA Procedure *Fix-it-Now Teams *Work Management Centers	*Stop Work Authority *Fix-it-Now Teams *Work Management Centers	*Fix-it-Now Teams *Work Management Centers +Employee Concerns Program +Safety Observers +Green Cards
Organized Communication					+Mgmt Evaluations +FEB Visits

Legend: +ISMS only in red; *Both in blue; -EWP only in green; No matches expected in gray area

3.3 Safety

3.3.1 Safety Implementation Detailed Planning

Table of Contents

Figure 3-12. Safety Implementation Planning Document

Safety implementation planning is an extremely useful communication tool for developing safety documentation. An example safety implementation planning document outline is presented in Figure 3-12. The primary purpose of this plan is to document the lower-level safety documentation development schedule and communicate the level of safety documentation that will be available at each stage of the project.

The Safety Implementation Detail Planning document contains the definitive statement of the project safety philosophy, objectives, top-level safety requirements, and basis for each safety document that will be developed for the project. The more complex the facility and the longer the project schedule, the more important the safety implementation plan becomes. For example, no definitive guidance is provided for the contents of a Preliminary Safety Analysis Report or a Limited Work Authorization. Therefore, the safety detailed planning document provides the regulators with the communication tool containing the detail that will be available for review at each critical decision point. This documentation could be as simple as identifying the PSAR chapters that would be developed or as complex as providing a description of the level of detail that will be provided in each section of the PSAR, based on the outline of the FSAR as contained in DOE STD 3009.

Thus, the Safety Implementation Detailed Planning document allows the project to document its graded approach to developing the safety documentation based on the hazard category of the facility and the overall complexity.

3.3.2 Safety Requirements

Safety requirements are controlled in the FDD and specific SDDs. For complex facilities, a single document may be beneficial in which all safety requirements are captures and controlled. In this case, a safety requirements document could be useful. The purpose of developing a safety requirements document is to provide documentation of safety-driven requirements and goals, as well as the basis for each. This would include the top-level design requirements based the hazard and processes within the facility. It would also include derivative requirements that are based on the specific design solutions to safety functions and the requirements derived from the design basis accident analysis demonstrating acceptability of the design solutions. It is important not to include requirements handled by national consensus codes and standards within this document, but only include those requirements driven by development of the facility authorization basis.

The safety requirements document is primarily a project tool used by safety professionals to document the breadth of the safety requirements in a single location. The implementation of these requirements in design and operation is via the Facility Design Description and System Design Descriptions. It provides a centralized location for safety professionals to document requirements that flow from the safety analysis, along with the bases for each requirement. This facilitates transfer into the applicable system design descriptions and the Facility Design Description as appropriate. The requirements should be developed and documented according to system or subsystem (i.e., by the System Design Description). Additionally, the function (safety classification that the requirement is helping to satisfy) should be captured. The function may be captured as a part of the requirement development or as a part of the basis for the requirement. Additionally, the highest safety classification (functional classification—Safety Class, Safety Significant, or lower-tier classification) that the requirement is helping to satisfy should also be documented in either the basis or with the requirement.

3.3.3 Authorization Basis Documentation

Authorization basis documentation development should be initiated early in the conceptual design stage. The hazard analysis document, developed in accordance with DOE-STD-1027 determines the level of safety documentation that is required for the project and facility. In addition, the Preliminary Hazard Analysis will provide input to the definition of Design Basis Accidents (DBAs) and the extent of accident analysis that will be required to complete the safety documentation. Other than providing feedback and in some cases driving design and design requirements, the development of the safety case can lead to additional safety documents being required. If the construction schedule is extremely long (for example, caused by long-lead material requirements), then a Limited Work Authorization (LWA) may be required for DOE to authorize limited construction activities (including early procurement). This permits construction activities or procurement of long-lead materials to be initiated prior to approval of the PSAR.

As no specific DOE guidance has been provided to cover a Limited Work Authorization, it is imperative that the plans be delineated in the safety implementation plan and approved by DOE. Critical to the acceptability of the LWA is demonstrating that the significant issues have either been addressed or that remaining issued are not affected by the LWA, making the risk to DOE for moving forward acceptable.

The stages of SAR development are described in the various design stages described in Section 3.2 of the Practices. Note that with integration of the safety documentation task and the design tasks, the SAR becomes a managed report that is issued at decision points (or based on an annual update) to document the current status of the safety case for the facility. Thus managed, the PSAR is developed to the point of turnover and DOE acceptance, the PSAR becomes the FSAR with minimal project impact or delays.

3.3.4 Safety Evaluation Report

The DOE project manager or ES&H manager should develop a plan to review the authorization basis documentation and prepare the Safety Evaluation Report (SER) for the project. The safety review plan should be updated for each project stage to define the level of review that will be applied for the next critical decision. The SER is developed consistent with the requirements of DOE-STD-1104 “DOE, Review and Approval of Nonreactor Nuclear Facility Safety Analysis Reports.” An example Safety Review Plan outline is presented in Figure 3-13. Critical elements of the Safety Review Plan are the schedule, staffing, review guidelines, method of documenting comments, and method of closure on comments. Overall, the Safety Review Plan should also define the expectations for the safety documentation and the purpose of the review. Thus, this would change for each project stage.

3.3.5 Unique Aspects of Projects Modifying Existing Facilities

In general, the principles associated with developing a safety case and supporting a modification to an existing facility and a greenfield facility are effectively the same. However, there are unique aspects associated this a modification that need to be highlighted to assure that adequate attention is paid to them by the project.

3.3.5.1 Develop and Define Objectives and Safety Scope of Modification

Whether or not a modification is specifically intended to affect the safety of facility operations, there is always a desire to use the opportunity to improve the safety design of the facility. This desire should be effectively balanced against available funding and schedules. The existing facility safety basis should be consulted and any new hazards identified and analyzed. During conceptual design, additional or improved safety controls should be proposed and ranked according to safety benefit and cost. Use safety design criteria as part of the input for identifying the range of improvements that could be made—like fixing single failure points, seismically-upgrading, providing backup power, failing to preferred mode, etc.

Figure **3-13.** Example Safety Review Plan Outline

CONTENTS

9. SER PREPARATION AND ASSIGNMENTS

   9.1 SER Preparation Team Organization
   9.2 Process for Identifying SER Issues
   9.3 Review Guidelines to be Used in the SER
   9.4 SER Preparation, Review, and Approval Process
   9.5 Quality Assurance Requirements for the Preparation of the SER
   9.6 SER Content and Format Guidance

10. MILESTONE SCHEDULE

11. PROFILES OF PSAR REVIEW AND SER PREPARATION PARTICIPANTS

12. RECORD KEEPING

13. REPORTS

   13.1 Meeting Minutes
   13.2 Formal Technical Evaluations
   13.3 Informal Technical Evaluations
   13.4 Periodic Progress Reports
   13.5 Draft SER

14. REFERENCES

Appendix A—Definitions

Appendix B—PSAR Content Expectation and Safety Review Guidance

Appendix C—Independent Review Process

During preliminary design, safety controls that will be provided should be identified and justified. Controls that were proposed but not selected should be justified.

This approach can provide the greatest safety benefit possible within funding limits. With a clearly defined and justified project scope, the "ratchet effect" (when outside project reviewers try to get everything fixed under the sponsorship of the project) can be answered with a technically defensible justification.

3.3.5.2 Fund and Schedule Safety Analyses and Review in Project Plan

In addition to the analyses discussed elsewhere in this section, the existing FSAR will need to be updated to reflect the modification, and DOE will need to complete an SER. These efforts can require significant effort and time, but should be managed as tasks within the project so that they will incur a minimal impact on project cost and schedule.

3.3.5.3 Understand Effects of Changes

New or revised analyses should identify the effects of proposed changes on facility safety. Available design documents and safety basis should be researched to understand why the facility is the way it is (or why it is not the way it appears it should be). Special attention is necessary to make sure that changes will not violate any previous assumptions or restrictions. Consider new hazards that will be introduced, and how existing hazards are affected. Determine whether the hazard categorization of the facility will change. Determine whether any systems will change their safety classification.

A second project decision is likely to be required based on the review of existing documentation. If the facility is new or has undergone design basis reconstitution to document the technical baseline in a Facility Design Description and System Design Description, then the documentation for the facility should be adequate and the project will be modifying existing documentation. However, if the facility is lacking good technical baseline documentation, then a decision will be required as to the depth of design basis reconstitution that the project wants to or is required to fund in order to provide adequate documentation for the project. This should be performed on a graded approach based on facility resources. The facility modification project can not be encumbered by the second project to reconstitute the facility baseline. Only that portion of the facility that is being modified is required to be captured in updated technical baseline documents. However, the project could use the Facility Design Description/System Design Description development process to begin the baseline reconstitution process.

3.3.5.4 Obtain DOE Review and Approval of Safety Aspects of Change

An unreviewed safety question determination should not be done, because DOE must always approve major modifications to existing facilities. But the same analyses is done, analyzing the safety of the changed facility. New or revised analyses should be started during the conceptual phase and updated during each phase. The difference between existing and proposed safety should be highlighted. DOE reviews and approves the analyses. At the end of the project, the FSAR is updated to capture the change and DOE provides an SER.

If the facility has a Facility Design Description and System Design Description, then documentation of the change is easily tracked via the revisions of affected documents. If the Facility Design Description and System Design Descriptions are not available, then as a minimum a change package should be prepared that depicts affected portions of the facility both before and after the modification. This will help preserve a record of the facility configuration that is important for analyzing future changes. In addition, sometimes changes cause unforeseen problems that can only be remedied by restoring the original configuration.

3.3.5.5 Compare Codes and Standards for the Existing Facility to Current Codes and Standards

New construction generally conforms to current codes and standards. With modification work, there may be some conflict between the codes and standards that the existing facility conforms to and the current codes and standards.

During the conceptual design phase, codes and standards that apply to the work are identified according to the Integrated Safety Design process and approved by DOE. During the preliminary design phase, research and review of the existing design baseline includes identification of the codes and standards originally applied to the construction of the existing facility. Past modifications may also have incorporated codes and standards that are different from the original construction. The report on the preliminary design phase should document a comparison of existing versus current and identify how differences will be resolved. The preliminary design report should specifically indicate which baseline codes and standards will continue to apply, where codes and standards will be updated, and what new codes and standards will be applied.

3.3.5.6 Account for Changes to the Loading of Support Systems

Evaluate whether the modification will increase or decrease loading of support systems. Identify existing margins and spare capability that may be depleted. Identify existing redundant support systems and determine whether redundancy will be maintained. Identify any support systems that will require modification to increase capacity, preserve redundancy, or provide new redundancy. Evaluate and properly preserve interfaces between new or modified systems and existing systems, paying special attention to interfaces between safety and non-safety structures, systems, and components.

The impact on support systems is one of the reasons for involving all stakeholders in project planning. Before the project is initiated, the complete impact on the facility and site infrastructure needs to be identified. Impacted systems or organizations (such as fire protection) may need to change existing programs or procedures to accommodate the design modification. Lead times for infrastructure upgrades at existing facilities could be the driving factor in the overall project schedule.

3.3.5.7 Ensure Safety During Modification Work

Apply traditional Integrated Safety Management practices to the planning associated with performing physical work and the execution of the construction phase of the modification. Unique aspects of modification work that may require special attention include maintaining the integrity of existing confinement barriers, protection of construction personnel from existing nuclear hazards, and whether credible construction accidents are bounded by the facility's existing safety basis.

3.4 ENVIRONMENT

The International Standards Organization (ISO) 14001 has been used by many sites and projects to implement an environmental management system as required by Executive Order 13148. The Executive Order does not require compliance with ISO 14001, however the principles contained in ISO 14001 can serve as the central framework for the environmental management system (EMS) required by the Order. Due to the number of sites implementing or gaining certification in the standard, the EMS will be discussed in terms of the standard. An EMS is composed of the elements of an organization's overall management structure that address the immediate and long-term impact of its products, services, and processes on the environment. An EMS provides order and consistency in organizational methodologies through the assessment of environmental impacts, assessment of legal and regulatory requirements, allocation of resources, assignment of responsibilities, and ongoing evaluation of practices, procedures, and processes.

The environment includes the surroundings in which an organization operates. This includes water, air, land, natural resources, flora, fauna, humans, and their interrelation. Environmental requirements, documentation, and implementation are integrated into the project programs and overall schedule via the Project Execution Plan. The method for implementation is via the ISMS described in this section of the Practices and in Section 3 of the manual.

3.4.1 Requirements and Guidance

Environmental management processes are required by Executive Order 13148, "Greening the Government through Leadership in Environmental Management" and discussed in DOE G 450.4-1A, "Integrated Safety Management System Guide." The environmental baseline for the project is established prior to any work being performed at the site. For ER projects, the environmental baseline is typically provided as an integral part of the baseline risk assessment. Implementation of the required environmental management system may be through compliance with or certification against ISO 14001, "Environmental Management Systems—Specification with Guidance for Use." The project EMS may be part of a larger site-wide EMS or for a new greenfield project that is not on an existing DOE site, developed only for the project.

The project should be implemented under a written environmental management process in order to anticipate and meet growing environmental performance expectations and to ensure ongoing compliance with national and international regulatory requirements. This could be a site process or one developed specifically for the project.

In general, if an organization is going to implement an ISO 14001 environmental management system, the management program should achieve the following:

- Assess potential environmental impacts.
- Assess legal and regulatory requirements.
- Establish an appropriate lifecycle environmental policy, including a commitment to prevention of pollution.
- Determine the legislative requirements and environmental aspects associated with the project activities, products, and services.

- Develop management and employee commitment to the protection of the environment, with clear assignment of accountability and responsibility.
- Encourage environmental planning throughout the full range of the organization's activities, from raw material acquisition through product distribution.
- Establish a disciplined management process for achieving targeted performance levels.
- Provide appropriate and sufficient resources, including training, to achieve targeted performance levels on an ongoing basis.
- Establish and maintain an emergency preparedness and response program.
- Evaluate environmental performance against the policy and appropriate objectives and targets, and seek improvement where appropriate.
- Establish a management process to review and audit the EMS and identify opportunities for improvement of the system and resulting environmental performance.
- Establish and maintain appropriate communications with internal and external interested parties.
- Perform a senior management review of the system to ensure that the process remains effective.
- Encourage contractors and suppliers to establish an EMS or other type of written environmental management process.

Environmental considerations are part of most projects, regardless of the project type (e.g., modification, construction, environmental cleanup, facility startup). Environmental planning is needed early in each project's planning stage to avoid delays and ensure compliance with applicable regulations. Projects for federal agencies are often subject to more regulations than for commercial projects. In addition, compliance actions for environmental regulations often invoke specific time frames and/or a sequence of process steps. Examples include obtaining a Resource Conservation and Recovery Act (RCRA) permit or completing the National Environmental Policy Act (NEPA) process, which involves issuing such documents such as Records of Decision (RODs) and Findings of No Significant Impact (FONSIs). It is important for the project management team to understand the regulatory framework for the various environmental regulations—particularly those associated with environmental cleanup. The typical steps each project needs to complete to ensure it meets its environmental stewardship commitment are outlined in Section 3.2 of the manual.

3.4.2 Environmental Management System (EMS)

The environmental aspects of the project should fit within the EMS for the site. Note that if the project is not located on a DOE site with an existing EMS, a site EMS needs to be developed for the project. The five elements of EMS defined in ISO 14001 are:

- Policy
- Planning
- Implementation and Operation
- Checking and Corrective Action
- Management Review.

The elements of the EMS can be compared to the five core functions of the ISMS as described in Figure 3-14. Although there is not a one for one comparison of the elements of the EMS with the ISM core functions, the key aspects of each are embodied in the other. In effect the EMS establishes boundaries for performing work based on the potential impact on the environment. Implementation though the ISMS provides specificity to the middle element of the EMS (Implementation and Operation), when the work is actually performed.

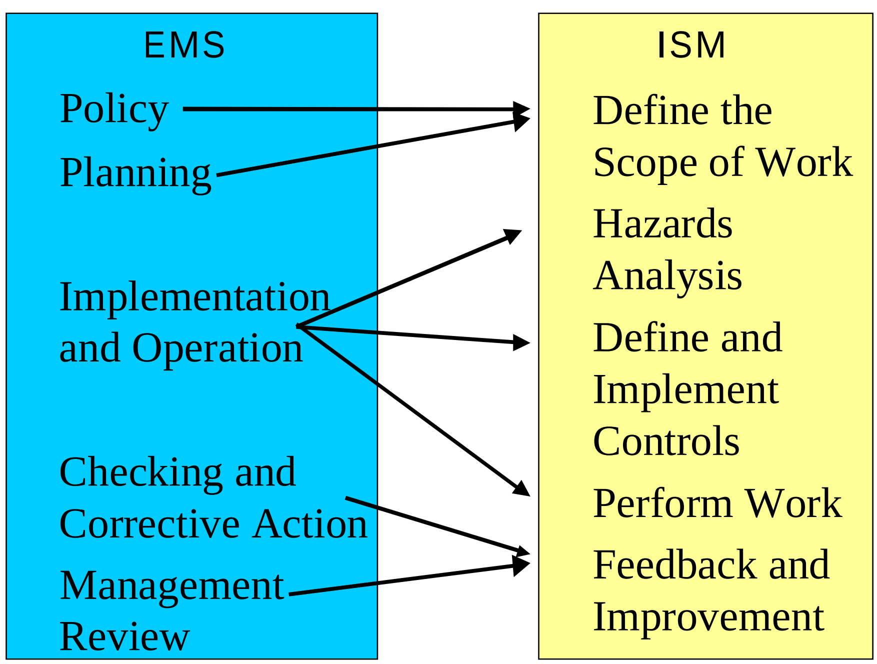


Figure 3-14. EMS / ISM Element Comparison

An example outline of an EMS and activities flow chart are presented in Figure 3-15.

ELEMENTS

Purpose: The purpose of this section is to provide basic information that describes the elements of the EMS. The outline below is derived from the same elements included in the International Standard ISO 14001 EMS. The numbering system is that used by the Standard as well. This is used for easy reference.

Describing the elements in this way helps align the EMS with the ISO 14001 Standard. A copy of the standard requirements is included at the end of this EMS description. Sections are tabbed to match the specific ISO element for easy reference.

Elements:

4.1 General Requirement (No references necessary)
4.2 Environmental Policy
4.3 Environmental Planning
- 4.3.1 Environmental Aspects
- 4.3.2 Legal and Other Requirements
- 4.3.3 Objectives and Targets
- 4.3.4 Environmental Management Program

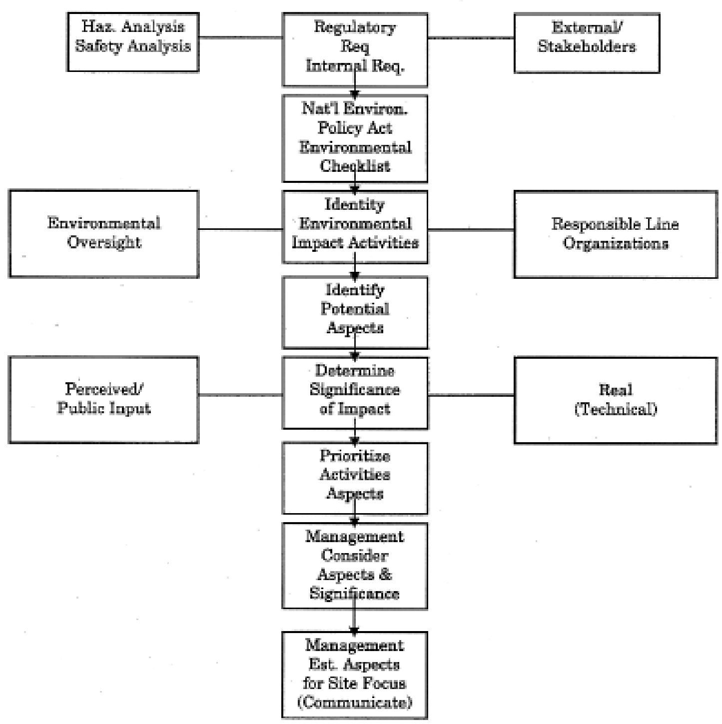
4.4 Implementation and Operation
- 4.4.1 Structure and Responsibility
- 4.4.2 Training, Awareness, and Competence
- 4.4.3 Communication
- 4.4.4 Environmental Management System
- 4.4.5 Document Control
- 4.4.6 Operational Control
- 4.4.7 Emergency Preparedness and Response

4.5 Checking and Corrective Action
- 4.5.1 Monitoring and Measurement
- 4.5.2 Nonconformance, Corrective, and Preventive Actions
- 4.5.3 Records
- 4.5.4 Environmental Management System Audit

4.6 Management Review

Figure 3-15. Example EMS Outline and Related Documentation

ACTIVITIES - IMPACTS - ASPECTS



* Environmental Evaluation Checklist is a formal, proceduralized process applicable to new projects, new processes, changes to processes, new products, or any activity that has environmental potential.

** Impact significance is defined per NEPA in 40 CFR 1508.27. The definition requires that both the context (society as a whole, affected region, affected interests, and locality) and intensity (severity) of the impact be considered. A determination of the intensity of impacts considers the following: unique characteristics of he geographic area, the degree to which affects are likely to be controversial, are highly uncertain, may establish a precedent for future actions with significant effects, may adversely affect significant cultural, scientific or historic resources, or may adversely affect an endangered or threatened species, whether the action contributes cumulatively to a significant aspect, and whether the action threatens a violation of laws or requirements imposed for the protection of the environment.

Figure 3-15 (continued)

Preliminary environmental evaluations typical of a major project are organized as shown in Figure 3-16. Although a time line is assumed from the figure, no unique time line can be assumed. The purpose of this figure is to provide a visual depiction of the types of documents and/or activities that should be applied and the type of information included in the documentation.

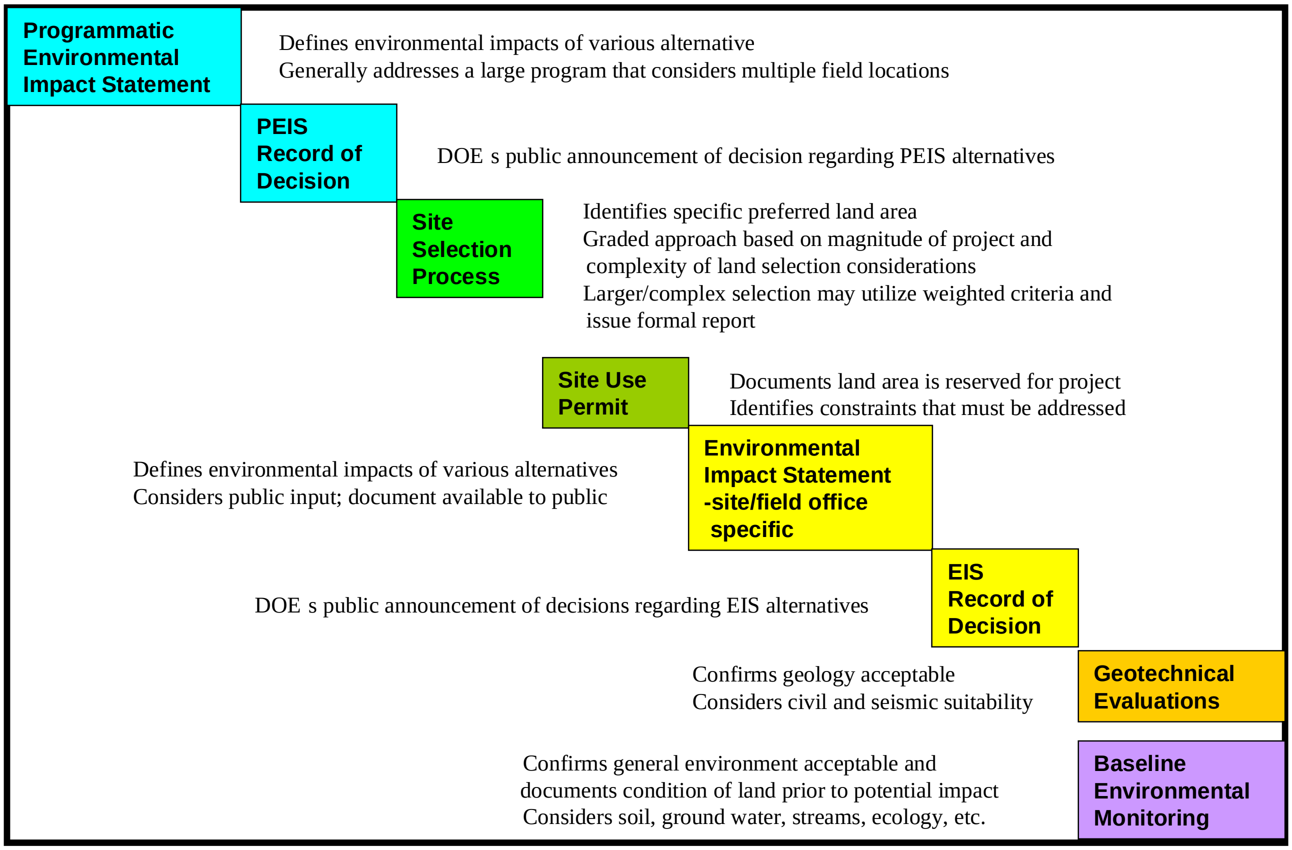


Figure 3-16. Project Preliminary Environmental Evaluation

To assure that an ISO 14001 EMS is adequately implemented in the ISMS, a crosswalk between the existing ISO 14001 and the ISM requirements is beneficial. A typical example is depicted in Figure 3-17.

Figure 3-17 ISMS Function Crosswalk with ISO 14001 Elements

ISO 14001 \ ISMS	Scope of Work	Analyze Hazards	Develop/Implement Controls	Perform Work	Feedback Improvement
Policy	*EMS Policy		*Policy Manual *Environmental Management Council *EMS Policy		
Planning	*Strategic Plan *Annual Operating Plan *Waste Management & Pollution Prevention Plans	*NEPA Procedure *Environmental. Monitoring Plan *Aspect Determination	*S/RID or Work Smart Standards		
Implementation & Operations			*Environmental Compliance *Operations *Management Req'ts and Procedures *Quality Assurance *Compliance Assurance	*Facility Specific Procedures *HAZMAT, HAZCOM, & Waste Handling Training	
Checking & Corrective Actions			*Records Management		*Performance Metrics *NCRs *EMS Audit *Effluent monitoring
Management Review					*Mgt Review Requirements *EMS Man Review Procedure *Citizens Advisory Board

Legend: +ISMS only in red; *Both in blue; -EWP only in green; No matches expected in gray area

3.5 QUALITY

3.5.1 Introduction

Quality Assurance is a tool to be used by the project manager to provide a level of assurance that the project is meeting the customer's requirement. Beyond that, nuclear and environmentally significant (regulatory driven) projects impose quality requirements to provide a basis for stating that the regulatory requirements (nuclear or environmental) have been met.

Whether the selected standard has 10 (414.1) or 18 plus 4 supplements and 3 appendices (RW-0333P), all quality programs are focused on providing the structured system that defines the control features that will demonstrate through objective evidence that the project requirements have been met. These control features are for the most part good business practices. These features document the design, have it reviewed, and have the changes controlled. Similarly, they describe the organization of the project and the quality-affecting activities. In summary, the quality program's function describes the extent the project will control all of the key aspects such as organization, design, procurement, documents, records, inspection, testing, defects, maintenance and test equipment, and the process the project will use to review these aspects and make sure the control features continue to function as planned.

3.5.2 Quality Assurance Plans (QAPs)

In a general sense, the more risk involved in the project the more control is needed. As an example, Appendix 1 provides a matrix of the procedure to meet the requirements for compliance with the Office of Civilian Radioactive Waste Management (OCRWM), Quality Assurance requirements, and descriptions for Radioactive Waste Management (DOE RW-0333P). The project implementing documents section provides a general listing of the organizations, including QA, that need to have documented methods for meeting the customer-mandated requirements for the Civilian Radioactive Waste Management Program.

Appendix 2 provides a matrix of typical project procedures needed to define a quality program that will meet the requirements of 10 CFR 830.120.

Appendix 3 provides a table of contents for a quality assurance plan that describes how the project will meet the requirements of either DOE Order 414.1A or 10 CFR 830.120.

Appendix 4 provides an index of quality assurance procedures that would typically be prepared to meet the requirements of a nuclear project that must comply with 10 CFR 830.120 and has selected ASME NQA-1 has the industry standard to follow. Supporting procedures from other organizations such as engineering, procurement, records, testing etc. would all show up in the matrix (Appendix 3) attached to the QA Plan for the project. This set of procedures provides the control system for the project to assure that the customer's requirements for the project will be met. It takes all of the project participants to make this happen.

3.5.3 Quality Program Tailoring and Categorization

The description in Section 3 and appendices provide a view of very detailed programs with all the elements essential for control of high-risk, potentially significant environmental or radiological activities. The determination of the impact on project mission, safety and the environment of any activity is required early in order that appropriate controls can be instituted to minimize the potential for significant issues occurring. As the risk of injury or insult reduces, the controls can also be reduced. Another aspect that is also considered when categorizing systems or items is the potential impact to project cost or schedule.

Significance Categorization:

The project should develop a list of items and activities as early as possible and determine the significance of the item or activity to the success of the project. Things that should be considered in assigning significance include:

a) Radiological or Industrial Safety to the public and worker

b) Potential to impact the environment

c) Potential to impact the acceptability to the customer (Can you prove it is good?)

d) Potential to impact project completion date

e) Potential to impact project cost

f) Regulatory significance

g) Public perception

h) Others

Once the significant discriminators for the project items or activities are determined they can be used to apply the appropriate level of review and oversight.

For example, in low-level radioactive waste shipments, the radiological hazard is low, the customer acceptance needs are high, and the public perception (if waste is spilled on the highway) is significant. Therefore one would expect to apply a significant effort to assure that the shipping containers and DOT shipping requirements are met. This typically would include independent inspection of the procurement and receipt integrity of the containers, independent verification of the radiological conditions, and an independent verification that the loaded containers meet the DOT shipping requirements for placards, manifest, and such.

Another example, is the high-level vitrified waste being prepared for storage in a federal repository. The quality requirements for the chemicals that are used to manufacture the waste are limited to the process controls necessary to assure that when the chemicals are mixed with the waste, the resulting mixture will produce a vitrified waste that complies with the repository requirements so that high-level waste quality program requirements are not applied to the chemicals.

Quality Program Tailoring

Quality program tailoring is accomplished by applying only those quality program elements to an item or activity that are required to accomplish the goal of having an item or activity meet the mission needs and customer requirements.

The key is to having trained and qualified quality personnel with a sound technical background who can understand both the quality program requirements and the important technical aspects of the project activities.

Categorization usually is used to determine the need to apply quality program controls. Once the need to assign a level of assurance is determined, the description and extent of this assurance should be a mutual agreement between the quality organization and the technical organization. Typically, the responsible engineer and the quality engineer will discuss the item or activity and reach a conclusion on the appropriate level of oversight needed to assure the acceptability of the item or activity for the project. Factors that enter into the determination include:

Items

a) Will the item be contaminated in use?

b) Can the item be removed or repaired?

c) Will the item cost the project money or affect the schedule if it is procured incorrectly?

d) Are the dimensions important to it's function?

e) Is the material important?

f) Does the customer requirements dictate specific needs?

g) Others.

Activities

a) Does the activity require independent oversight (e.g., for safety or project Requirements)?

b) Is a record required that the activity was performed correctly?

c) Other.

In some cases, project or customer requirements will include specific action be taken such as receipt inspection of all procured items or vendor qualification for all items that are fabricated to project design.

All of these decisions and activities associated with selecting the appropriate quality requirements for an item or activity are part of the specific tailoring of project quality requirements to the circumstances and require knowledgeable and experienced people in the quality assurance organizations as well as the technical organizations. Tailoring is the tool that the project uses to minimize the quality cost for the project by applying appropriate controls based on risk.

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Practice 4

4

Project Execution Plan

PROJECT EXECUTION PLAN

4 PROJECT EXECUTION PLAN

The Project Execution Plan (PEP) is the primary agreement on project planning and objectives between the Headquarters program office and the field, which establishes roles and responsibilities and defines how the project will be executed. The Headquarters or field program manager and/or the Federal project manager initiates a Project Execution Plan. Development of the preliminary Project Execution Plan can be started by the prime contractor or M&O/M&I at the same time as development of the Acquisition Plan or shortly after.

4.1 OVERVIEW

The PEP uses the results from other planning processes and combines them into consistent and coherent documentation that is used to guide both project execution and project control. The PEP documents planning assumptions, documents tailoring decisions, and provides the basis for subsequently measuring progress.

The PEP will be tailored to meet the specific needs and complexities unique to each project. The degree of tailoring will be documented in the PEP. All PEP elements placed under configuration management.

All projects will have both preliminary and final Project Execution Plans that are approved by the appropriate SAE/AE. The preliminary PEP is initially prepared prior to CD-1, Approval of Preliminary Baseline Range. The Final Project Execution Plan will be finalized prior to CD-2.

Over the course of a project, the Project Execution Plan shall at a minimum address the following:

- mission need justification/project objectives
- project description
- organizational structure; roles, responsibilities, and authorities; and accountability, including decision authority for Headquarters and field element, program and project management and support functions, safety analysis support functions such as health physics, Environment, Safety and Health, National Environmental Policy Act documentation, etc.
- resource requirements

- technical considerations, including
  - extent of research and development and its relationship to the project
  - value engineering
  - test and evaluation
  - Environment, Safety and Health
  - Integrated Safety Management
  - sustainable building design
  - configuration management
  - system engineering, and
  - reliability, maintainability, and quality assurance
- project cost, schedule, and scope baselines (or preliminary baseline ranges for a preliminary Project Execution Plan), including separately identified contingencies, and descriptions of Levels 0, 1, 2, and 3 baseline change control thresholds
- life-cycle cost
- alternatives, trade-offs
- risk management plan
- Integrated Safety Management Plan
- project controls system and reporting system
- Acquisition Plan

The Project Execution Plan must reflect the point at which the project is complete. The plan shall indicate at what point the project manager's responsibility ceases and an operating organization takes over. Specifications must clearly delineate the end product involved, not only for purposes of project execution, but to indicate the specific parameters at project completion.

4.2 Purpose

The Project Execution Plan represents an agreement between the AE and the project on project planning and objectives. The PEP documents project baselines. The PEP also supports DOE Headquarters oversight activities and assists in communication with stakeholders and regulators.

The Project Execution Plan documents the plan for project execution, monitoring, and control, and guides the project manager throughout the life of the project to ensure consistency in management, adherence to process, and clarity of roles and responsibilities.

4.3 Application

4.3.1 Establishment/Maintenance

The Project Execution Plan is prepared through a collaborative effort between DOE and the contractor, but is the prime responsibility of the Federal project manager and the IPT. Development of the PEP can be started at the same time as development of the acquisition plan or shortly after. However, preparation of the two plans should be synchronized. If the approved Acquisition Plan indicates that the M&O/M&I contractor has a role in the acquisition of the project as prime contractor/integrator, the M&O/M&I contractor may participate with DOE in development of the Project Execution Plan.

Development of the PEP will begin in the preconceptual and conceptual project phases, and the draft PEP will be approved for internal use at completion of conceptual design. The final PEP will be approved at approval of CD-2, and will be updated once a year or as necessary to maintain information current and to include new information. If the information required in the PEP exists in other project documents, that information can simply be summarized and referenced in the PEP, but not included.

4.3.2 Approval

The Project Execution Plan will be approved by the Deputy Secretary, Program Secretarial Office, the program manager, the operations/field office manager, and the Federal project manager.. The DOE field element shall submit the plan for approval to the management responsible for the Approve Performance Baseline Critical Decision-2 before the start of the project execution phase. Where plans are approved by the DOE field element, they must be coordinated with the cognizant Headquarters program manager prior to DOE field element approval.

4.3.3 Project Execution Plan Elements

A minimal elaboration on the contents of each of the PEP elements listed in Section 4.1 follows. In many cases, smaller projects will cover their systematic project management approach in simpler methodology such as project data sheets or memoranda of understanding (MOU). These may partially satisfy the need for a separate PEP.

a) Title Page shall contain the officially approved project title, DOE program, unique project number, and revision date.

b) Introduction shall contain the project title, unique project number, a brief history, and summary of the project including the purpose, summary goals, and timeframe. It will also contain any major assumptions made in preparing the PEP, such as on smaller projects the manner in which the PEP has been streamlined yet still meets requirements.

c) Justification of Mission shall be a brief (2 to 6 pages) that will provide the program mission/goals, why the project is needed, and how the project will support these goals. It will describe project technical, schedule, and cost objectives as well as performance indicators for attainment of these summary goals. Goals are to be expressed in an objective, quantifiable, and measurable form. This statement should be considered the "anchor" of other planning documentation.

d) Project Description shall describe what is going to be done and how it will be accomplished. It will provide a summary of technical and expected functional performance, describing what is to be accomplished, developed, or constructed. The emphasis for this section will evolve from high-level functions in the preconceptual phase to functions at a system and subsystem level in the conceptual phase to a component level in the execution phase.

e) Management Structure and Responsibilities shall describe the project management structure, including its integration into the program management structure. It will identify all significant interfaces with other contributing organizations as well as lines of authority, responsibility, accountability, and communication. Definitions should be provided for all significant interfaces in the project such as between project geographic locations, functional units, and contractors. Any MOUs between project participants will be included. Interface management control techniques that will be utilized and procedures for resolving conflict between respon-

sible organizations shall be noted. It will also identify specific management tools to support management in planning and controlling the project and describe the use of special boards and committees. This section should address any requirements for a resident office, including duties and authority.

This section will consist of descriptive text accompanied by appropriate organization and related charts. The charts should be comprehensive in scope and at a level of detail consistent with the current project phase of the acquisition cycle. Any special agreements between participants that are not documented in MOUs shall be noted.

Roles, responsibilities, authorities, and accountabilities for DOE, other federal agencies, and participating contractors will be described. Project support functions shall be included, such as health physics, safety, quality, National Environmental Policy Act, etc.

f) <u>Work Breakdown Structure (WBS)</u> shall define all authorized project work through the use of the WBS that will be used in managing the project. The WBS structure and WBS dictionary will be provided with elements displayed and defined at least through level 3 of the project. For guidance on preparation of the WBS, see PMBOK-Project Management Body of Knowledge, PMI Standards Committee.

g) <u>Resource Plan</u> shall provide a short graphic description of funding and expenditure plans including the total project cost profile, budget by funding category, and the total project life-cycle cost plan by fiscal year. Categories shall include budget outlay (BO), actual and estimated budget authority (BA), and appropriations at fiscal year end. Prior year experience may be combined. BO shall be on an accrual basis. Suggested reference guidance includes Project Data Sheet Preparation Instructions and OMB A-11, Report Preparation Guidance

h) <u>Project Technical, Schedule, and Cost Life-Cycle Baselines</u> (including separately identified contingencies) will provide the key life cycle planning against which work execution is measured.

The technical baseline shall be derived from, and traceable to, mission requirements and is the basis for establishing both the schedule and cost baselines in an integrated manner.

The schedule baseline section shall include a listing of major events, with a discernible critical path, major milestones, Critical Decision points, and their anticipated approval dates. Lower-level schedules that are to be developed and maintained will be identified and significant milestones with other federal agencies shall be identified in this section. Schedule logic shall portray major activities and significant interfaces and constraints.

Cost baseline estimates and staffing plans shall be provided at summary levels of the project WBS and be time-phased consistent with the schedule baseline for deferred multi-year periods. Estimated costs beyond the multi-year period of definition will also be included to provide life-cycle costs. Reference guidance includes Practice 7, Baseline Development and Validation, and the Integrated Planning, Accountability, and Budgeting System (IPABS) Handbook.

i) <u>Baseline Change Control Approval Thresholds</u> shall be those specified by DOE O 413.X, Attachment S, and shown in Figure 4-1. This section of the PEP will further define those change thresholds defined by the column designated as Level 2/3. Any other agreed to deviations from DOE O 413.X must also be specified, as must any authority delegation for threshold approvals.

j) <u>Risk Management Assessment</u> shall provide, at a minimum, a discussion of levels of risk associated with technical requirements; schedule; cost; Safeguards and Security; and Environment, Safety, and Health; together with action(s) that will be taken to mitigate, reduce, or eliminate the risk, see Practice 8, Risk Management.

k) <u>Project Controls System Description</u> will provide a description of the integrated systems used for monitoring and control of the project including the use of work planning, scheduling software, cost control, funds control, project status meetings, project status reporting, and the various parameters of the change control process. The use and approval of applicable contingencies and reserves will also be described. Items that should also be addressed include the project management philosophy toward project control goals and objectives, and integration of the systems. Each system shall be discussed with respect to required documentation, level of control, relationship to other system documentation, and change control procedures to be utilized.

A reporting and project review plan should be included in the PEP. This will specify the format, content, and frequency of both periodic reports and periodic reviews. Reports and reviews shall be timely, thorough, and accurate.

Approval Authority

Level 0 Changes	-	Secretarial Acquisition Executive
Level 1 Changes	-	Program Secretarial Officer
Level 2 Changes	-	Federal Project Manager as delegated by the Operations/Field Office Manager or Program Manager
Level 3 Changes	-	Contractor

2.a Major System Projects

Major System	Level 0	Level 1	Level 2/3
Technical Scope	Changes to scope that affect mission need requirements.	Changes to scope that may impact operation functions functions, but does not affect mission need.	As defined in the Project Execution Plan.
Schedule	Six or more months increase (cumulative) in a project-level schedule milestone date.	Three to six months increase (cumulative) in a project-level schedule milestone date.	As defined in the Project Execution Plan.
Cost	Any increase in Total Project Cost and/ or Increase in Total Estimated Cost.**	Project cost sub-elements as defined in the Project Execution Plan.	As defined in the Project Execution Plan.

2.b Other Projects

Other Projects*	Level-1	Level-2/3
Technical Scope	Changes to scope that affect mission need requirements.	As defined in the Project Execution Plan.
Schedule	Six or more months increase (cumulative) in a project-level schedule milestone date.	As defined in the Project Execution Plan.
Cost	Any increase in Total Project Cost and/or increase in Total Estimated Cost.**	As defined in the Project Execution Plan.

* For Other Projects less than $100M, the PSO may delegate Level-1 approval authority to the Program Manager or operations/field office manager. General plant projects, accelerator improvement projects, capital equipment projects, and operating expense funded projects that are $5M or less are the responsibility of the Federal Project Manager as delegated by the Operations/Field Officer Manager.

** Total Estimated Cost does not apply to environmental restoration projects.

Figure 4.1. Baseline Change Approval Thresholds

Additional reference guidance may be found in Practice 10, Project Control; Earned Value Management Implementation Guide (ANSI/EIP-748-1998); Practice 17, Assessments, Reviews and Lessons Learned; and the EM Integrated Planning, Accountability, and Budgeting Systems (IPABS) Handbook.

l) Acquisition Strategy Plan provides a discussion of the proposed or current method of accomplishing the project including the use of internal labor, contracting and subcontracting, and the type of contract vehicles. It is prepared initially at a high level and from the DOE perspective. Subsequently, it will be further enhanced by contract procurement strategy details.

m) Alternate, Tradeoffs will identify alternative project architectures (solutions) considered and evaluated. As the design phase matures, a number of more detailed alternatives (for segments of the design) will be considered through the use of a design evaluation technique called tradeoff studies. This is in order to obtain the one solution that best accomplishes the identified function or set of functions and satisfies project requirements. Both categories will be documented in the PEP to provide tracking of the various approaches considered during the project's evolution. Also see manual, Section 9, Alternatives Analysis and Trade-off Studies.

n) Technical Considerations will include a number of topics including the extent of research and development and its relationship to the project technology, e.g., technology development plan, the applications of value engineering, test and evaluation, safety; configuration management, system engineering, reliability; maintainability; and quality assurance. Each topic will be addressed on its use and extent of application to the project during each phase. Existing documents and plans may be referenced if appropriate. The design philosophy and approach shall also be described. Any special or unusual technical considerations will be documented. Two examples of what could be appropriate elements of the technical consideration section are provided for understanding:

— Systems Engineering Management. Where systems engineering is an integral part of project execution, this section should describe the extent to which systems engineering shall be used, how the process will be managed, and who should be responsible for various aspects of management.

— Configuration Management. This section describes the details of technical interface management and control during project execution. The configuration management plan should highlight identification, recording, and reporting of product interface data.

o) Integrated Safety Management Plan. An Integrated Safety Management Systems Description shall be prepared that will describe how the principles of ISMS are integrated into the overall management of the project. The ISMS helps to ensure that worker, public, and environmental safety protection are incorporated into the planning and performance of all tasks by each core function. ISMS spans the lifecycle of the project, and the plan will need to be reviewed regularly to ensure it is current with the evolving project (DOE Policy 450.4, Integrated Safety Management Systems Policy).

4.3.4 Consideration of Additional PEP Elements

The following elements may sometimes be a part of the PEP. This is not an all inclusive list, but rather some typical important project elements that need to be considered as being possible PEP segments. These determinations will be made jointly by responsible DOE and contractor management under the tailored approach. The determination is not whether the plan exists or not, but rather, whether it will be considered as an element of the PEP. In many cases the requirement will be covered by site-level, rather then project-level, documentation.

1. Project Quality Assurance Plan specifically addresses the 10 criteria of DOE Order 5700.6C or DOE Order 414.1 arranged in three categories (management, performance, and assessment) to ensure that quality assurance will be achieved throughout the life of the project and that "lessons learned" will be documented for future projects. In most cases a site-wide plan should already be in existence that can be referenced or adapted by the project. (AMSE/Nuclear Quality Assurance Standard-1 (NQA-1)

2. Safeguards and Security Documentation is usually satisfied by referencing existing site planning. However, if definition of a project results in unique situations of a safeguard or security nature, then a specific plan may need to be developed as determined by the responsible project manager.

3. Transition and Closeout Plan may be developed as part of the PEP to assure smooth transition from project (construction) to user (operation) or from demolition to stewardship. Generally, this is a lower-tier plan that is generated between the user, the constructor, and the project manager. For operating facilities, there are two types of turnovers, a system turnover and a room/area (partial) turnover. A system turnover includes the hardware (piping, pumps, conduit, control panels, etc.) that combine to perform a given function. A room/area turnover consists of a visual examination of the physical appearance,

cleanliness, and overall completeness of the room/area. The room/area turnover includes installed hardware, but only the extent of its appearance, completeness, identification markings, coating, insulation, etc. Elements of this plan shall generally include: permits, schedules, NEPA documentation, turnover boundaries, drawings, records and deliverables, punchlist items, walkdowns, responsibilities, and interfaces.

d) Startup Plan is generally prepared by the user/project to assure a smooth transition from the project to the user, and to assure that appropriate budget is identified for the startup activities and subsequent operational phase. The startup plan establishes a cost-effective sequence of testing and test support activities deemed necessary to provide confidence that all testing (acceptance, preoperational, and operational) will be successful.

In addition to providing a plan for test and test support activities, the startup plan outlines organizations responsible for managing and performing startup activities. This includes describing the participating organizations' management responsibilities, interfaces, lines of authority, accountability, qualifications, and independent verification. Finally, the plan establishes the rationale for the kind, amount, and schedule for required project testing activities.

The depth and complexity of each facility-specific startup plan will vary depending upon project complexity. Startup plans must thoroughly address the following elements: administrative management of startup activities, work management of startup activities, support for startup activities, and test engineering activities.

4.4 SUMMARY

As stated elsewhere, the content and extent of detail for the Project Execution Plan will vary in accordance with the size, complexity, and phase of the project. For smaller projects, many of the sections addressed will be included in other documents that will adequately cover the topical area of interest. An example might be the project data sheet which could provide funding plans. A simple reference to the latest revision of the data sheet would document the funding requirements. For large, complex projects more detail is generally necessary for complete understanding of a PEP element. Various factors must be considered, weighed, and judgment exercised to determine the final scope and content for any particular project's PEP.

Practice 5

Technology Management

5 TECHNOLOGY MANAGEMENT

5.1 INTRODUCTION

5.1.1 Purpose

Technology development is the process of developing new or unproven technology; the application of existing technology to new or different uses, or the combining of existing and proven technology to achieve a specific goal. Technology development associated with a project must be identified and completed in order to establish credible technical, schedule, and cost baselines for subsequent implementation and project control. Projects with concurrent technology development and design implementation proceed with ill-defined risks to all three baselines. The purpose of this section is to present those elements of technology development required to ensure the project satisfies its intended purpose in a safe and cost-effective manner that will reduce life-cycle costs and produce results that are defensible to expert reviewers.

5.1.2 Scope

The scope of this chapter encompasses initial technology development and evolution of that development throughout the life cycle of the project. The following topical areas are addressed:

- Technology development program plans
- Process needs identification, selection and evaluation
- Performance verification
- Plant support
- Technology reviews

5.2 Requirements and Guidance

Various technical baseline deliverables, including associated technology development, are produced as a project evolves from preconceptual design to operation. Table 5-1 provides a matrix of the maturity level of typical deliverables at each project phase. The technology development process is not limited to the pre conceptual and conceptual development phases, but instead transitions throughout the life of the project. The process recognizes the evolution of the project and the iteration necessary to continue support of the design. This integrated technology development approach also addresses emerging issues related to the technology that are driven by the design process.

Figure 5-1 identifies the integration of technology development phases with project phases. In practice, technology development precedes design, which is followed by design implementation (construction). This is depicted in Figure 5-1 with bold arrows signifying completion of technology development activities supporting the follow-on design process.

The following sections provide the requirements necessary to ensure that technology development activities are brought to a level of maturity and transitioned for each project phase with a continued effort to reduce technological risk.

5.2.1 Technology Development Program Plans

Technology development plans are prepared when new technology development activities are identified during project planning. Technology plans provide a comprehensive planning document describing technology development activities required for the successful execution of the project and the development relationship to the overall project scope and schedule relative to project phases. Areas addressed by the plan should include process needs identification, selection, evaluation, performance verification, and demonstrations.

In support of the technology development, a roadmap is developed to provide the technology development path forward to successful deployment of the selected technology. A workscope matrix is then developed that expands on the roadmap. The matrix provides the high-level details of each segment of research and development, assigning responsibility for the execution of each segment and documenting the path through each segment in the form of logic diagrams that tie to the roadmap.

Preconceptual Design	Conceptual Design	Preliminary Design	Final Design	Construction, Startup/ Turnover
Cost: DOE approval if conceptual design costs exceed $600,000 limit **Maturity:** Need to know estimated conceptual design cost	**Cost:** DOE Authorization **Maturity:** Need cost range estimate of Preliminary Design; Target Project Cost	**Cost:** Congressional funding **Maturity:** Project performance TEC and TPC performance baseline including contingency at CD-2	**Cost:** No special requirements to go from final design to construction—under change control **Maturity:** CD-3 pre-construction release	**Cost:** No requirements—under change control **Maturity:** CD-3 released, CD-4 complete at closeout
Schedule: No schedule requirements to go from Pre- to Conceptual Design	**Schedule:** DOE Approval **Maturity:** Need Preliminary Design schedule	**Schedule:** Project schedule **Maturity:** Project TEC/TPC	**Schedule:** No special requirements to go from final design to construction—under change control **Maturity:** Not Applicable	**Schedule:** No requirements—under change control **Maturity:** Not Applicable
Technical: Support the Conceptual Design Estimate **Maturity: *** • Assessments and studies • Design Criteria (Orders, regulations, codes & stds.) • Functions • Identify Technology Development activities • Information Utilization Strategy • Mission • Operational Strategy and Automation Strategy • Performance Requirements • Preliminary Vulnerability Assessment Study • Preliminary Site Clearance Permit • Review of Alternatives • Risk Assessment • Site Selection Criteria • Small-Scale testing • Systems Engineering Management Plan	**Technical:** Support cost and schedule and Conceptual Design Report (CDR) **Maturity: *** • Alternative Studies • CDR • Complete Facility Design Description, approve Facility Functional and Operational Requirements, and draft Program Requirements • Complete system design description • Conceptual Vulnerability Assessment Study • Develop Key Technical Parameters • Identification of system boundaries • Identify engineering development versus proven process • Identify permitting requirements • Draft Interface Control Documents (ICD)	**Technical:** Engineering development completed, with contingency for open issues **Maturity: *** • Complete Accident Analysis • Component requirements identified • Configuration Mgmt. Plan • Facility Design Description completed • Final Characterization and Site Selection • Initiate Pressure Protection Plan • P&ID Rev. 0 • All Construction and Procurement Packages Complete • ICDs issued • Preliminary layout drawings of major components • Performance Verification a) Full-Scale Tests b) Refinement/Optimization —Engr.-Scale Tests —Integrated Runs • Material Balance	**Technical:** Complete design documentation **Maturity: *** • All detailed design drawings, calculations, specifications, etc., except field run items • Test Plans Issued • Construction Punchlist • ORR Planning and Preparation developed • Finalize Pressure Protection Plan • Site Clearance Permit • Testing requirements identified • All construction and procurement packages complete • ICDs issued	**Technical:** **Maturity: *** • All as-builts complete • Performance Verification a) Operating Parameters Definition b) Process Optimization • Task plans issued • ORR Planning and Preparations

Preliminary Design Authorized →
Project Baselines Established as TEC and TPC →
*Technical Maturity – those applicable deliverables necessary to proceed to the next project phase

Table 5.1. Project Design Phase Matrix

Preconceptual Design	Conceptual Design	Preliminary Design	Final Design	Construction, Startup/ Turnover
Technical Maturity continued: * • Technology Development Program Plan a) Program R&D requirements b) Define R&D program phase **Safety and Hazard Analysis / Vulnerability Assessments** • Draft Safeguards Requirements Identification ***Supported by:*** —Preliminary VE Study —Hazard Assessment Document —Proposed Process Material Flow • Emergency Preparedness Hazard Survey and Screen • Hazard Assessment Document (HAD) ***Supported by:*** —Facility layout —Hazardous material inventory	**Technical Maturity continued: *** • Identify preliminary structures and systems with preliminary safety classifications • Information Utilization Plan • Operational/Automation Plan • Preliminary Characterization and Site Selection • Proof of Concept Testing • Regulatory Management Strategy • Risk Management Plan • NEPA (EA, EIS approved) **Safety and Hazard Analysis / Vulnerability Assessments** • Preliminary Functional Classification ***Supported by:*** —Preliminary Hazards Analysis —Selected Alternative Study • Preliminary Shielding Analysis ***Supported by:*** —Facility layout —Radiological material location • SRI, Rev. 0 ***Supported by:*** —Conceptual VE Study	**Technical Maturity continued:*** • Reliability, Availability, Maintainability Evaluation • System Design Description at system level • System boundaries identified • Technology Development activities complete • Updated Risk Management Plan • Value engineering **Safety and Hazard Analysis / Vulnerability Assessments** • ALARA Review ***Supported by:*** —Preliminary Design • Automation and Information Design approach finalized • PSAR Rev. A • Preliminary Emergency • Preparedness Hazard Assess-ment ***Supported by:*** —PSAR Rev A —Preliminary Design —Project Cost Estimate	**Safety and Hazard Analysis / Vulnerability Assessments** • Accident Analysis ***Supported by:*** —Final Design —Final Functional Classification • Basis for Interim Operations • Criticality Analysis ***Supported by:*** —Final Design —Draft Vulnerability Assess-ment Report —Final Functional Classification —Administrative Controls —Final Hazards Analysis —Accident Analysis —Criticality Analysis • Final Shielding Analysis ***Supported by:*** —Final Design • Fire Hazards Analysis ***Supported by:*** —Final Design —Final Functional Classification • Preliminary technical safety requirements • PSAR Report —Emergency Action Levels	**Safety and Hazard Analysis / Vulnerability Assessments** • Emergency Preparedness Hazard Assessment • Final Fire Hazard Analysis ***Supported by:*** —Final Drawings —Walk down —Tests • FSAR ***Supported by:*** —As-builts —Final Hazards Assessment —Startup test results —Site Safeguards and Security Plan —Safeguards and Security Management Report —Final Vulnerability Assess-ment Report —Tests (force on force) • Technical Safety Requirements ***Supported by:*** —FSAR

Preliminary Design Authorized →
Project Baselines Established as TEC and TPC →
Technical Maturity – those applicable deliverables necessary to proceed to the next project phase
Permit Applications and Approval →

Table 5.1. Project Design Phase Matrix, cont.

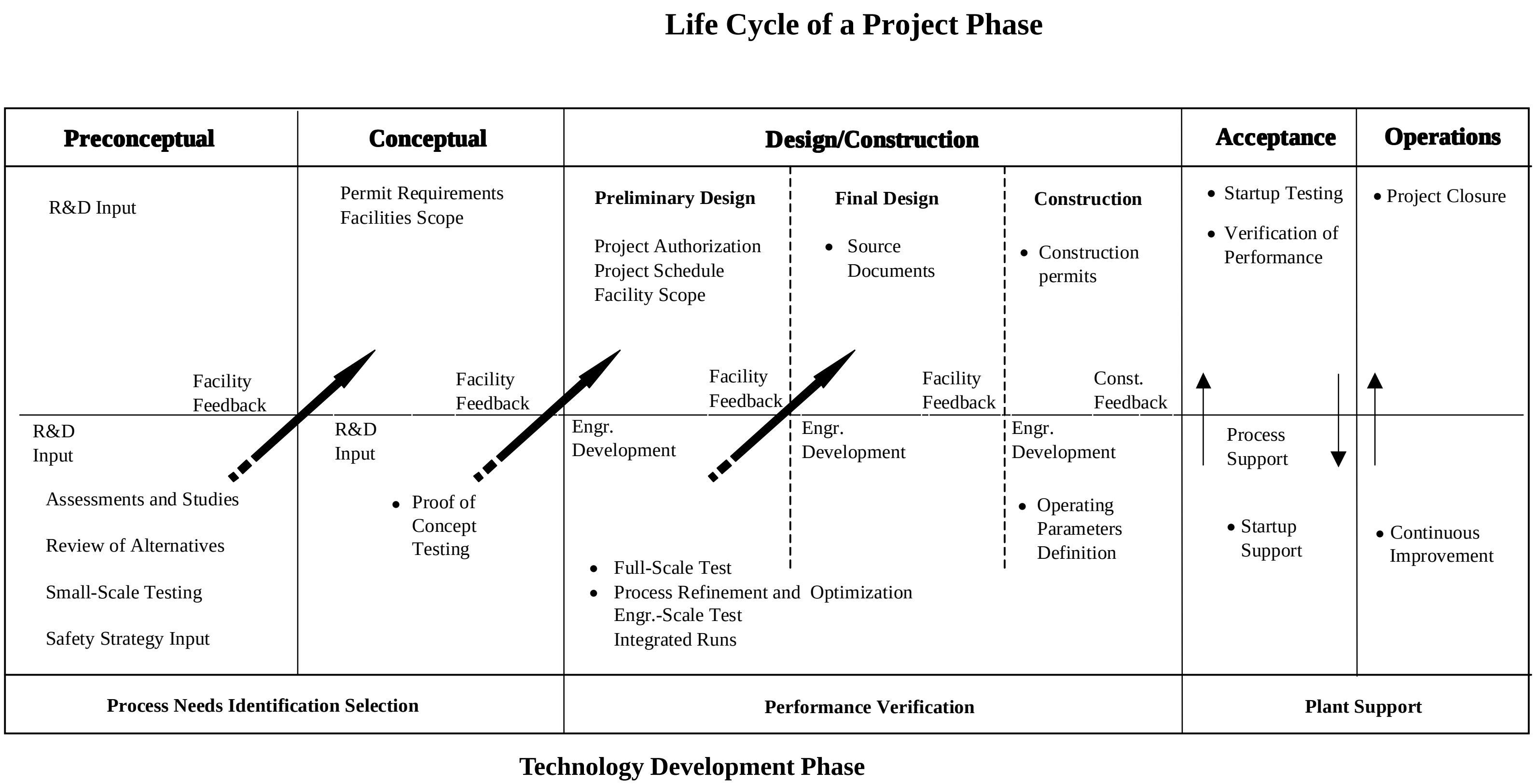


Figure 5-1. Technology Development Integration with Project Management

5.2.1.1 Process Needs Identification, Selection, and Evaluation

Process needs identification, selection, and evaluation occur during the preconceptual and conceptual design phases. Within these phases, the technology development program identifies and quantifies the needs and requirements of a system or component and associated risks. This may include laboratory or pilot work to better understand system or process performance. The product of these activities provides input to performance requirement documents and criteria.

The next step in this phase involves selecting equipment that meets the performance requirements or criteria. In the selection phase, existing developed equipment or processes are utilized to the maximum extent possible. However, in many cases, particularly those processes performed in hazardous or remote environments, the equipment may not be commercially available. In these situations, efforts are made to adapt commercial technologies to the specific environment and requirements. During this phase, the available equipment is compared and those identified as most closely meeting the defined requirements are selected for further evaluation.

Equipment and or process evaluation involves experimental or pilot facility testing of the process or equipment identified in the selection phase. Although the selection phase identified those processes and equipment that most closely meet design requirements, it is not uncommon for evaluation of those selected processes and equipment to identify areas where the process or equipment fails to meet requirements. In those cases, it may be necessary to return to the selection process to evaluate alternatives to the selected option.

The following subsections describe various activities utilized to support the identification, selection, and evaluation of the selected technology.

Assessments and Studies

Inherent with technology development is the risk associated with first-of-kind applications. A technical risk assessment should be performed to identify risks that may affect the achievement of technical objectives that ultimately affect schedule, cost, and performance. Results of technical risk assessments and risk handling strategies are factored into technical assessments and studies.

Technical assessments and studies are conducted during the preconceptual project phase to evaluate and select the design approach that best meets the customers' goals, objectives, and preliminary technical and functional requirements. Topics addressed during this activity should include, as applicable, process technology, facility concepts, major system concepts, component technology, and risk handling strategies identified through completion of technical risk assessments.

Review of Alternatives

Results of technology development assessments and studies are documented and reviewed to determine the validity of the approach that best meets project goals, objectives, and the physical, functional, performance, and operational requirements of the project at the least cost.

A team, consisting of members from the customer, engineering, operations and maintenance organizations, technology development program management, and selected subject matter experts, reviews the assessment and study results. The team review focuses on the results of the assessments and studies relative to the alternatives considered, evaluation of systems utilized to select the recommended design approach, and the potential cost savings. The objective of the review is to endorse the selected design approach, including development and testing of the technology development in subsequent project phases.

Small-Scale and Proof-of-Concept Testing

Small-scale and proof-of-concept testing is performed at the conceptual project phase to verify initial assumptions relative to system and process performance. Test results are compared with the initial input parameters. Based on the review of test results, refinements may be applied to assure that the technology concept meets project requirements prior to the start of project design activities.

5.2.2 Performance Verification

Performance verification occurs during the design and construction project phases. Once a process and or equipment has been selected and proven to perform in an acceptable manner, verification against the design requirements is performed to ensure that the process or equipment will perform properly in the operating environment. Verification addresses performance of the selected process and or equipment on both the component level and from an integrated systems perspective. Verification attributes may include checking that the operating parameters are within the operating envelope of supporting systems (e.g., power, feed rate, etc.) as well as meeting the physical expectations of the equipment and remote operation, or examining properties of material produced against the stated requirements.

Following verification activities, full-scale testing to assess the durability and reliability of the process and/or equipment is conducted. Integrated runs involving combining components, systems, or processes are performed to provide a demonstration of process conditions over extended periods of time and provide opportunities for process optimization. This testing phase is intended to prove that the long-term operating goals, especially where remote operations are required, can be reliably achieved while producing the end product at acceptable quality standards in a safe and controlled manner.

5.2.3 Plant Support

Following construction completion, support for the new technology is provided through start up and turnover to operations. This continued integration of technology development provides an opportunity for the operations technical staff to attain a better understanding of the technology application.

5.2.4 Technology Reviews

Technology review boards may be established to provide recommendations to the customer in terms of technology readiness and maturity. These boards serve in an advisory capacity at key project design phases such as Critical Decision 1, Critical Decision 2, etc. Membership consists of senior-level technical personnel and for continuity, key project personnel. The board is able to leverage outside experts as appropriate to contribute to the review process. A technology review report is issued after each review presenting the results of the review and specific recommendations relative to the design process.

Ad hoc teams of subject matter experts may perform additional technology development reviews at any point in the development process. These reviews target specific areas of development. The results from these reviews and recommendations are communicated to the project team and user.

5.3 RECORDS

Record retention is usually dictated by customer requirements. Typically project files are maintained through the various project phases until closeout. Because of the significant documentation generated by technology development activities, prudent judgment should be exercised prior to discarding any documented plans, reports or studies utilized to validate technology development selection and test results.

Practice 6

6

System / Value Engineering

6 SYSTEM/VALUE ENGINEERING

6.1 INTRODUCTION

The systems engineering process is a proven disciplined approach that supports management in clearly defining the mission or problem; managing system functions and requirements; identifying and managing risk; establishing bases for informed decision making; and verifying that products and services meet customer needs. An overview of the process is shown in Figure 6-1 below.

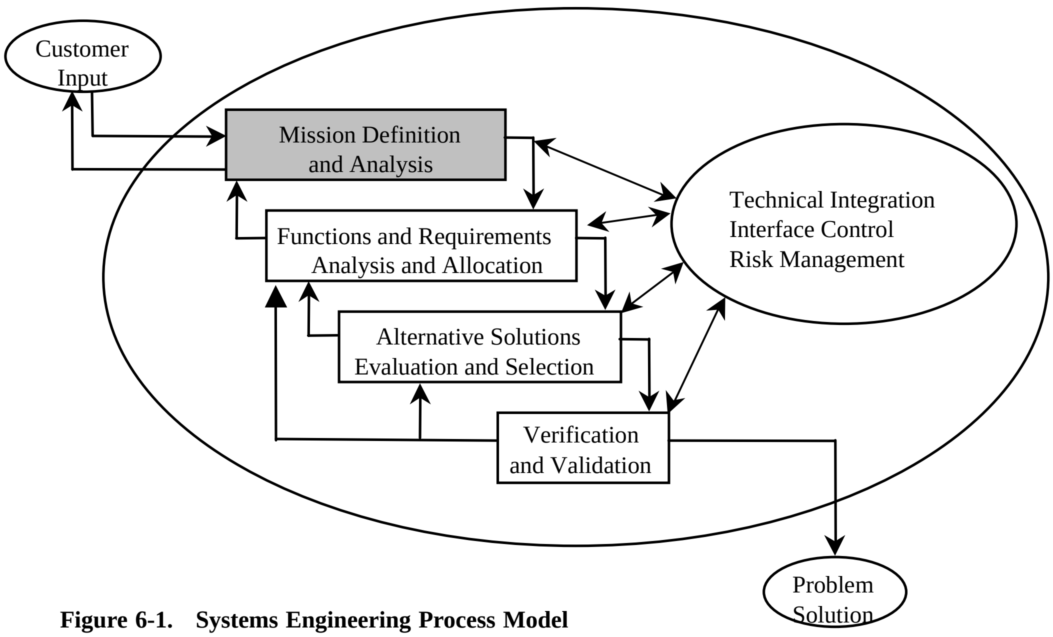


Figure 6-1. Systems Engineering Process Model

6.2 PURPOSE

The purpose of this systems engineering methodology process description is to identify the steps of the systems engineering process and to provide implementation guidance by presenting recommended proven techniques and methods that may be used for accomplishment of selected process steps. Specific techniques and methodologies used in implementation of the systems engineering process, describing and recommending acceptable "HOW TO's" for these steps are provided in this section of the manual. They are intended for application where specific methods are not covered by existing orders or other site-specific implementation tools.

6.3 Section Structure

This section is structured to describe the recommended methodologies and techniques in self-contained appendices. This structure accommodates both additions and revisions to these appendices as appropriate. The appendices are as follows:

Appendix A: Mission Definition

This appendix, with attachments, describes the steps and techniques to be used for mission definition in the application of the systems engineering process. The intent is to provide the user with guidance in working with their customers to translate stated needs and objectives into a concise and defendable definition of the work to be performed. The use of this guide will assist the user in developing the first step in the systems engineering process, i.e., clearly defining the problem and the customer's need.

Appendix B: Function and Performance Requirements Development

This appendix describes a process for the development of functions and performance requirements. Two methods for functional development are presented along with a discussion of performance requirements development and key attributes of good requirements. Example functional hierarchy diagrams, functional flow block diagrams, N-squared diagrams, and enhanced functional flow block diagrams are provided.

Appendix C: Alternative Studies and Value Engineering

This section, with attachments, describes the steps, tools, and techniques involved in performing Alternative Studies for selecting the optimum, most cost-effective, alternative that meets an activity's functions and requirements. Value engineering studies, which are a specific type of alternative study, are included.

D. Interface Control - To Be Developed

This section will describe the steps and techniques to be used for Interface Control in the application of the systems engineering process. The intent is to provide the user with guidance on how to identify and control system interfaces. Examples of how to document interface requirements are provided.

E. Systems Engineering Management Plan (SEMP) - To Be Developed

This section will describe the process involved in developing a system engineering management plan (SEMP) for a program, project or engineering task. This guide is written to be used in conjunction with the other sections in this manual. Guidance is provided on when a SEMP is needed and the recommended content of a SEMP.

Appendix A

MISSION DEFINITION

A.1.0 Introduction

Mission Definition establishes a solid foundation for proceeding with a work task by understanding, confirming, and documenting the change or problem being addressed and the criteria for success. Mission Definition is the initial activity performed in the application of the systems engineering process to define what must be done to satisfy the customer's need.

A.1.1 Purpose

The purpose of this guide is to describe the steps and techniques to be used for Mission Definition in the application of the systems engineering process. The intent is to provide the user with guidance in working with their customers to translate stated needs and objectives into a concise and defendable definition of the work to be performed.

The use of this guide will assist the user in developing the first step in the systems engineering process, i.e., clearly defining the problem and the customer's need. When properly performed, the Mission Definition step will answer the questions:

- What are trying to do (problem)?
- Why are we doing this (basis)?
- What is the initial state (present condition)?
- What are the boundaries (limits)?
- What is the outcome we seek (goals/objectives)?
- What is the final state (desired outcome)?
- How do we measure progress or achievements (success criteria)?

This guide will focus on the need to develop and document a concise definition of the problem, a firm basis and rationale for the work, the boundaries for the task, the customer requirements to be satisfied, and the goals and objectives to be achieved.

A.1.2 What is Mission Definition?

The key to the successful execution of a project or task, Mission Definition is the concise definition of the work to be performed with a clear understanding of the expected outcome. It is the translation of the customer's stated needs and objectives into the definitive set of the highest level function(s) and performance requirements necessary to accomplish the task, including the rationale and justification for each.

In this context, the term "mission" should be taken as the highest level function(s) to be performed by the task, i.e., what has to be done to change the initial state (current condition) to the final state (desired outcome). Mission Definition includes clear and concise problem and mission statements, the drivers that result in the need for the proposed activity, the highest level performance requirements associated with the major function(s), high level external interfaces, and identification of risks. Mission Definition may also include the identification of the highest level systems to be developed or modified by the task and/or proposed alternatives for consideration, as appropriate.

A.1.3 When Should Mission Definition be Performed?

Mission Definition is performed at the initiation of work with the customer and is the start of the systems engineering process, as shown in Figure 1. It serves as a "contract" with the customer to define, establish boundaries for, and document the scope and expectations of the task. A graded Mission Definition should be performed at the start of all tasks, regardless of complexity, to assure the work to be performed is precisely specified and understood. Whether the complexity of the task demands the use of software tools (e.g., CORE®) to capture the information, or is sufficiently simple to be "done in your head", the intent is fundamentally the same; develop, document, and agree to a complete, clear, and technically accurate definition of the work the customer needs to have performed.

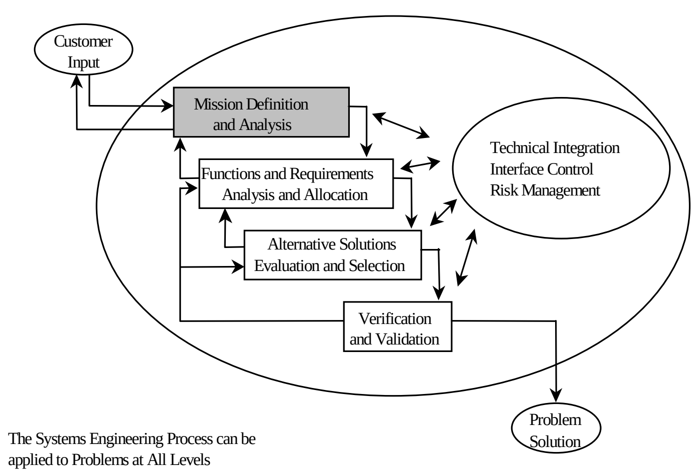


Figure A1. Systems Engineering Process Model

A.2.0 Methodology

The method used to perform the Mission Analysis, discussed below, is illustrated in the diagram shown in Figure A2.

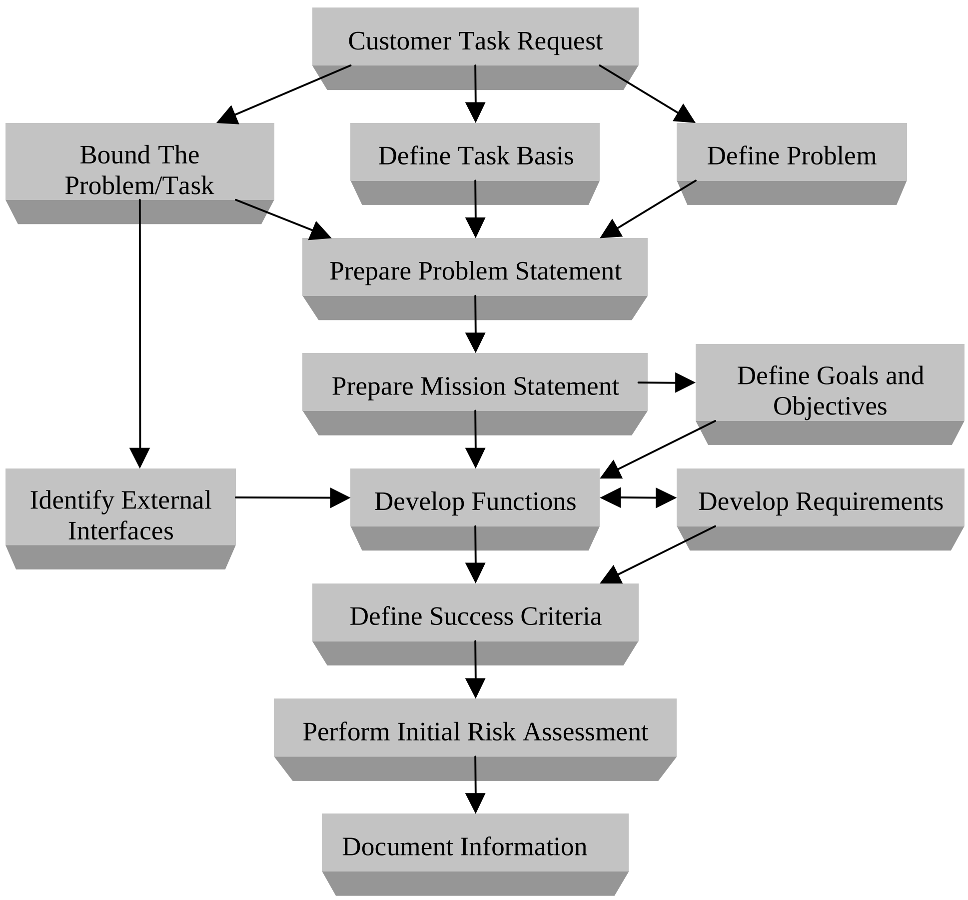


Figure A2. Mission Definition Methodology

A.2.1 Customer Task Request

Work is initiated following the receipt of a written or verbal request from a customer to perform a task. Ideally, the task request should identify the problem to be solved or corrected, the goals and objectives to be achieved, and the criteria for success. Often, however, this work request is incomplete, has no discernable basis or rationale, and/or worse, is a command to implement a preconceived "solution" to an undefined problem.

The customer task request should be used to initiate a probing discussion with the customer and their technical experts to begin to develop a precise and clear definition of the work to be performed. It is essential that all information obtained through these discussions is thoroughly documented.

A.2.2 Problem Definition and Customer Needs

This step of the process concentrates on clearly understanding and defining the problem and customer needs before proceeding with the task. Too many tasks are conducted without a clear understanding of what needs to be done. This leads to rework or possible failure.

A.2.2.11 Basis for the Task Request

To better define the task request, it is helpful to initially understand the basis and rationale for why the task is necessary. Question the customer on what the drivers are that make the requested work needed; ask why the customer needs to have the work done, for what purpose, and for whom.

To illustrate, consider the following example. Assume the customer's task request is to "Upgrade the Q-Lab Facility". By probing and asking questions as to why the upgrade is necessary and for what purpose, the responses may reveal:

WHY ⇒ "To support sample analysis for the Z-Line process"

"To demonstrate compliance with radiological control procedures"

WHAT ⇒ "Alpha, beta, gamma samples per sample analysis plan XYZ-99-1234"

WHOM ⇒ "For XYZ Division"

Identifying and documenting this information (such as in a systems engineering model) will capture this basis as justification for the task need. This exercise will help the systems engineer and the customer establish the boundaries of the problem or task. Weaknesses in the basis can also be examined to assure the initial task request is on solid ground and can stand up to scrutiny, if challenged. It will be shown later how this background will help refine the definition of the task and influence how the task proceeds.

A.2.2.2 2 Problem Definition and Problem Statement

Discussions are conducted with the customer and technical experts to better define and understand the problem that is being addressed and to assess the completeness of the input provided. Task requests generally present three possible scenarios or inputs: a problem is reported, a symptom is reported, or the customer requests something specific to be done (the "solution"). Since this input may or may not be complete or even address the real problem, it is necessary to gain a better understanding of why the request has been made to assure the real problem has been identified.

Ask the customer questions to assess the completeness of the input that was provided. The outcome of this questioning is an agreement with the customer on the problem to be solved, instead of symptoms to correct without solving the real problem. If the request is clearly a "solution" to an unstated problem, it is necessary to question the customer to identify the problem to be addressed.

Ask the following:

- Is this the problem or symptom of a problem?
- Should we be doing this task?
- Does it fix the real problem?
- Is this the best approach?
- Are the problem and task clearly defined?
- Who defined the problem and what's their background?

This line of questioning will cause the customer and experts to rethink the task request and ensure that the problem the task is attempting to solve has been identified. In addition, the system engineer should also have the customer analyze conditions and identify and evaluate possible causes of the problem to determine a root cause. Identification of a root cause will help focus the problem statement.

To illustrate, consider the Q-Lab example. The initial task request to upgrade the Q-Lab facility is really a predetermined solution to an unstated problem. Therefore, what is the problem the customer is trying to address? Questioning may produce the following replies:

- "Existing equipment is old and unreliable."
- "Results from Q-Lab do not meet QA accuracy requirements."

The customer may then think that based on these "problems" the logical "solution" is his original request to upgrade Q-Lab. In reality, these "problems" are really symptoms of the real problem. By analyzing the conditions in Q-Lab the root cause for the problem surfaces:

- "We presently don't have adequate capability to analyze the samples."

The real problem in this case is more accurately stated as:

- "The current sample analytical capability will not satisfy Z-Line requirements specified in sample analysis plan XYZ-99-1234."

The development work performed to establish the basis and rationale for the request (A.2.2.1), along with questioning the customer, provides the information needed to formulate an accurate problem statement. Obtain agreement with the customer that the problem has been accurately stated and document the problem statement. By correctly stating the problem, the potential for additional viable alternative solutions for consideration is introduced.

A.2.2.3 Mission Statement

By understanding the exact problem being addressed, a clear and complete mission statement for the requested task can be written. Essentially the mission statement captures the overall function the task must perform to satisfy the stated problem. In our Q-Lab example, knowing that the problem is that the current capability is inadequate, the mission statement can be stated as:

"Provide the analytical capability to perform sample analysis to satisfy the Z-Line process."

This mission statement thus becomes a refinement of the task request. Notice that this is considerably different than the original request. As written, this mission statement opens up the possibility for other alternatives that could also satisfy the need, e.g., a new facility, perform the analysis elsewhere, share analysis with other labs, etc. It is also evident that the original task request to upgrade the Q-Lab is now one possible solution for consideration instead of the only solution.

A.2.2.4 Mission Goals and Objectives

Once the mission statement has been prepared, the overall goals and objectives for the task may be established. Often this effort will be a revision to the initial goals/ objectives provided with the task request to better align them with the mission statement. The systems engineer and the customer should establish a mutually agreeable set of goals and objectives for the task.

Goals and objectives identify the desired conditions the customer would like to have achieved when the task is completed, and therefore, they provide a measure or "target" for performing the task. Unlike a requirement however, goals and objectives are those conditions that are desirable yet cannot be readily quantified or tested. For this reason, a goal or objective is a condition or end state that the task should strive to attain, yet it is not necessarily required to be achieved for the task to be successful. (Specific task requirements, developed later in the systems engineering process, will provide the measures for task success.)

Returning to the Q-Lab example, the customer may have originally stated a goal related to the completion of the requested upgrade to the Q-Lab. Instead, a more appropriate goal for the task may be:

"Maximize the capability to perform the sample analyses needed to maintain the Z-Line process operation."

The corresponding objectives are:

- "Increase the reliability of sample analysis methods"
- "Maximize efficiency of analysis operations"
- "Minimize sample turn-around time"

Again, goals and the objectives are related to the redefined task as clarified by the problem and mission statements.

A.2.3 Functions and Requirements

With a clear problem statement and mission statement prepared, and the task goals and objectives stated, the system engineer may now focus on developing the upper level functions and requirements that will shape the definition of the task. Refer to Appendix B, "Function and Performance Requirements Development" for guidance on the development and proper writing of functions and requirements. Again the customer's technical experts are instrumental in defining the requirements and the upper level functions that must be performed to achieve the mission and satisfy the problem. Once the task functions are known, the associated requirements for each function can be identified and linked to the functions. It is crucial that the basis and justification for each requirement be identified and documented.

Initially, the customer will have “drivers” or “originating requirements” for the task. Originating requirements are generally the requirements that surfaced when the basis and rationale for the task request were determined (see A.2.2.1). These requirements usually are very general in nature, but they provide the basis for the definition of the functions. The functions that are needed to satisfy these originating requirements are the upper level functions required for the task. These are the actions necessary to convert the initial conditions to the final desired state. The identified functions, in turn, may also prompt additional requirements that must be addressed, such as a performance requirement that is used to indicate the limits of the function.

The systems engineer works with the customer to assist in the proper identification and formulation of the functions and their definitions. If not intuitively clear, it is important to capture a precise definition of what the function means. The functions developed at the Mission Definition step only focus on the highest level, very broad functions that must be performed. It is not necessary to develop a detailed set of functions yet, and the systems engineer should keep the customer focused at a high level. Resist the temptation and natural inclination to drive down into increasing detail. Detailed functional analysis, performed later in the systems engineering process (refer to Appendix B), will decompose these functions into increasing levels of detail. Question the customer and the technical experts to ensure that all functions that must be performed to achieve the mission are identified.

The highest level functions can be considered an expansion of the mission statement, i.e., they provide additional clarity on what must be done to achieve the mission. In effect, the highest level functions are actually a decomposition of the mission statement. These functions better define the elements that must be considered by the task, and therefore provide an improved description of the scope of the effort. It is very important that these functions are not written based on a particular design solution. To illustrate, the Q-Lab example mission statement reads:

“Provide the analytical capability to perform sample analysis to satisfy the Z-Line process.”

This mission can be decomposed into several high-level functions that are necessary to achieve the mission:

"Receive Samples."

"Perform Sample Analysis."

"Operate Facility Infrastructure."

It can be seen from the example that the highest level functions include additional elements that must be part of the scope of the task to be successful. The function to perform the sample analysis is determined directly from the originating requirement for sample analysis for the Z-Line process. However, provisions must also be included to receive and handle the samples prior to analysis, and facility service systems (e.g., heating, ventilation, water, instrument air, etc.) must be available and operable as needed to support the analysis function. Note that the functions do not specifically favor or suggest any single potential solution.

Once the upper-level functions are identified, all originating requirements and any subsequently derived performance requirements are traced and linked to the appropriate function. This relationship defines and bounds the scope of the task and indicates the measures for success for each function. Performance requirements are derived from the customer's expectations for how well each function is to be performed. Each performance requirement must be stated in quantitative terms. For the Q-Lab example, the following examples of requirements may be identified and linked to the defined functions:

Function: "Receive Samples."

Originating requirement: "Receive alpha, beta, and gamma samples."

Function: "Perform Sample Analysis."

Performance requirement: "Analyze 50 samples per month."

Function: "Operate Facility Infrastructure."

Originating requirement: "Provide contamination control ventilation."

Performance requirement: "Hood ventilation air flow shall be a minimum of 125 linear feet per minute."

Again, it is not the intent to perform a detailed requirements analysis during Mission Definition. Instead the effort is limited to the originating requirements stated by the customer and any clarifying performance requirements, either given or derived, that help to define the expectations for each function.

A.2.4 Interfaces

The external interfaces for the task are documented to delineate the boundaries and specify the inlet and exit conditions for the task. The identification of external interfaces must include all pertinent interfaces. For the Q-Lab example, the external interfaces are the samples to be analyzed from the Z-Line process on the front end, and the sample analysis data on the back end. In addition, it is also necessary to include sample waste disposition as an exit interface.

A.2.5 Success Criteria

After the task has been thoroughly defined, and the functions and requirements have been identified, the criteria to be used to claim success are determined. Success criteria are the measures that the customer will use to judge whether the final state achieved by the task meets expectations and is acceptable. Question the customer and his or her experts to identify and specify the high level attributes and indicators that are important to the success of the overall task. As with requirements, these measures must be written in quantitative terms such that achievement can be determined. For the Q-Lab example success criteria might be:

- "Demonstrated ability to analyze samples within accuracy constraints specified in sample plan XYZ-99-1234."
- "Sample turnaround within the schedule requirements needed to support the Z-Line process."

A.2.6 Initial Risk Assessment

Potential risks associated with any aspect of the task should be identified and an initial assessment performed to determine if further evaluation is necessary as part of the task performance. Refer to Section 3.8, "Risk Analysis and Management," for guidance on evaluating risk. Any potential technical, cost, or schedule risks should be considered and subject to a risk screening. Any risk that could potentially have a significant negative impact to the completion of the task should be documented as part of the Mission Definition. A detailed risk analysis will be performed during the task to evaluate the severity of any identified risks and establish a plan for risk mitigation.

The screening of any identified potential risks relies on the expertise and judgement of the systems engineer, the customer's technical experts, and other subject matter experts. Since risks are inherent in any task performed, it is essential that serious consideration be given to identifying risks and properly screening the severity of the impacts due to the risks. Risks must never be downplayed.

Considering the Q-Lab example, a potential risk that may be possible is:

"New, untested analytical technology is necessary to analyze samples with the precision required by the Z-Line process."

This risk could have potentially serious negative impacts on the technical success of the task as well as on the cost and schedule. A detailed Risk Analysis will be necessary to manage the impacts associated with this risk.

A.2.7 Documentation

It has been noted repeatedly in this guide to document the information that has been generated. The importance of thorough, detailed documentation of the information obtained and developed during Mission Definition cannot be emphasized enough. Considerable effort has been spent to define and justify what has to be done to satisfy the customer's need. In addition, a significant amount of supporting information is developed and should be captured. This information forms an agreement with the customer on the exact scope to be addressed and establishes a baseline for the task.

Information may be documented by any suitable means. Simple text, tables, matrices, etc. may all be used as appropriate to capture and display task information. The use of specialized systems engineering software may be helpful to better document information on complex tasks. It is essential, however that the information is captured and presented in a manner the customer can use and readily understand. In all cases, have the customer review and concur with the Mission Definition prior to proceeding with the process.

A simple method for documenting the Q-Lab example used in this guide is shown in Attachment A.3.1. This example simply captures the information in a narrative style.

Attachment A.3.2 presents a sample of the use of CORE® to document the same information from the Q-Lab example used in this guide. The accompanying descriptive text that would be entered into the CORE® model for each element in Attachment A.3.2 would capture the detailed information that was generated. The software-defined relationships depicted in the diagram establish the links between the elements (e.g., functions, risk, requirements, etc.) entered into the model.

A.3.0 Attachments

A.3.1 Q-Lab Mission Definition Example

A.3.2 Q-Lab Mission Definition Using CORE®

Attachment A.3.1 - Q-Lab Mission Definition Example

Task Request:
Upgrade the Q-Lab Facility.

Basis:

Why:	To support sample analysis for the Z-Line process. To demonstrate compliance with radiological control procedures.
What:	Alpha, beta, gamma samples per sample analysis plan XYZ-99-1234.
Whom:	For XYZ Division.

Problem Statement:
The current sample analytical capability will not satisfy Z-Line requirements specified in sample analysis plan XYZ-99-1234.

Mission Statement:
Provide the analytical capability to perform sample analysis to satisfy the Z-Line process.

Goal:
Maximize the capability to perform the sample analysis needed to maintain the Z-Line process operation.

Objectives:
Increase the reliability of sample analysis methods.
Maximize the efficiency of analysis operations.

Minimize sample turnaround time.

Functions and requirements:

Function 1:	Receive samples
Requirement:	Receive alpha, beta, gamma samples
Function 2:	Perform sample analysis
Requirement:	Analyze 50 samples per month
Function 3:	Operate facility infrastructure
Requirement:	Hood ventilation air flow shall be a minimum of 125 linear feet per minute

Interfaces:

Input:	Alpha, beta, gamma samples
Output:	Sample analysis data Sample waste

Success Criteria:

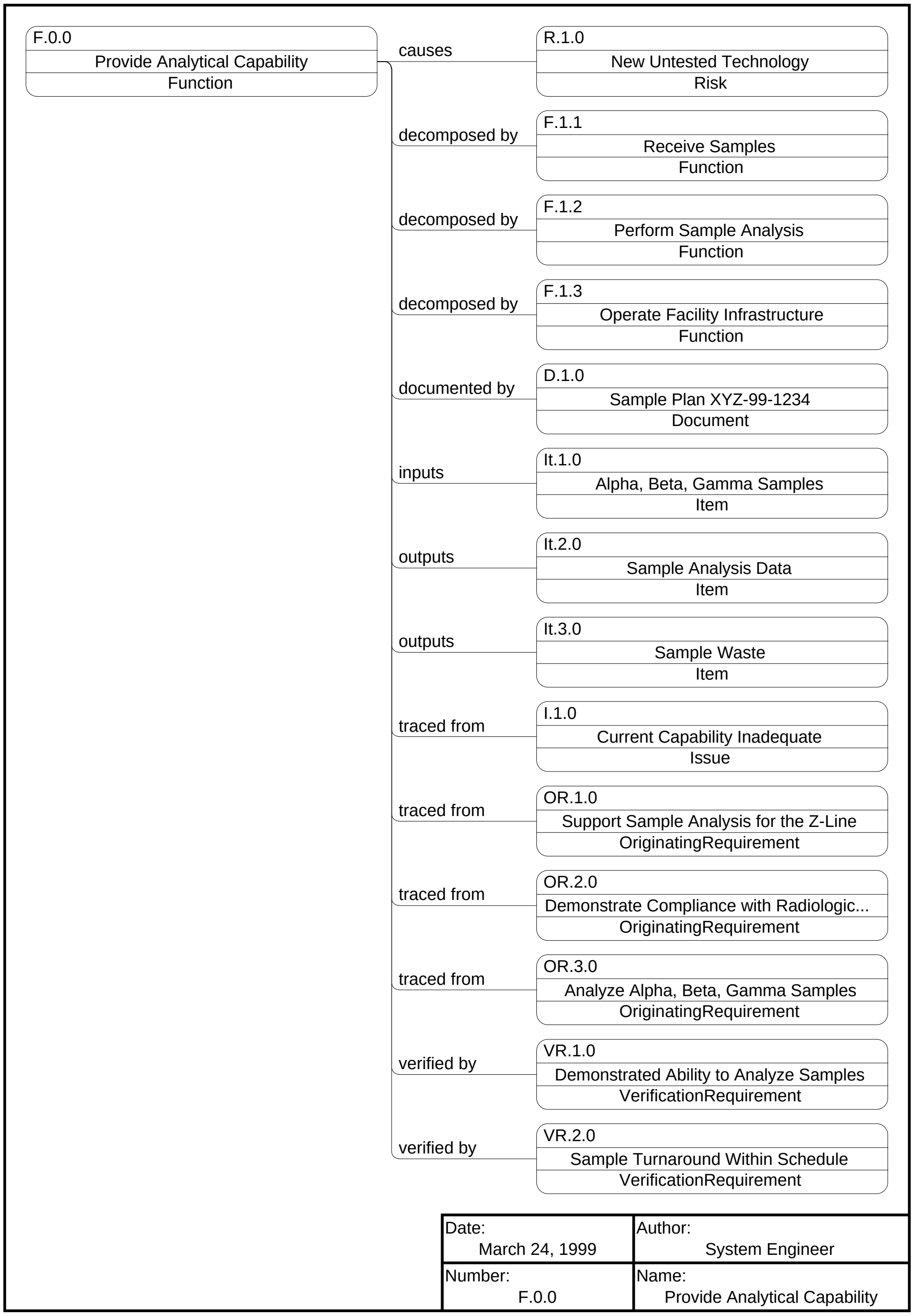
Demonstrated ability to analyze samples within accuracy constraints specified in sample plan XYZ-99-1234.

Sample turnaround within the schedule requirements needed to support the Z-Line process.

Risk:

New, untested analytical technology is necessary to analyze samples with the precision required by the Z-Line process.

Attachment A.3.2 - Q-Lab Mission Definition Using CORE®



Appendix B

FUNCTION AND PERFORMANCE REQUIREMENTS DEVELOPMENT

B.1.0 Introduction

This guide describes a process for the development of functions and performance requirements. The development of functions and performance requirements is at the heart of the systems engineering process. Functions describe what must be accomplished and performance requirements describe how well functions must be performed. Function and performance requirements development is not a standalone step but is instead one portion of the systems engineering (SE) process as a whole. This guide only addresses the function and performance requirements development portion of the process. Other guides provide assistance in completing the remaining system engineering process steps (e.g., Mission Definition, Functional Acceptance Criteria Development, Interface Control, Life Cycle Cost Analysis, Systems Engineering Management Plan Development).

B.1.1 What Are Functions?

A function is written most simply as a verb and noun combination (e.g., “filter particulates” or “measure temperature”). A function transforms inputs into desired outputs. For example, consider the function to “filter particulates.” The function transforms an input containing particulates into two outputs, one with and one without particulates.

A function is a statement that provides a basis for a system to exist. It is a task, activity, or action that must be performed. What is the system there for? What does it do? A function describes what the system must do in order to meet the system’s mission.

A more complete format for writing functions is to include the operating condition or accident / event when the function has to be performed. The suggested format for writing functions per the Writer’s Guide for the Preparation of Facility Design Descriptions and System Design Descriptions (Reference D.3.2) is as follows: “(action verb and subject) during (operating condition or accident / event).” This additional information is necessary in order to clarify the function. Consider the “filter particulates” function again, does this function have to be performed under accident conditions or is it only required for normal operations?

If the function were written as “filter particulates during normal operations and all design basis accidents,” the purpose of the function would be more clearly communicated.

Every function has at least one performance requirement associated with it. A performance requirement quantitatively defines how well the function must be performed.

B.1.2 What Are Performance Requirements?

A requirement is something that the system must meet in order for it to successfully perform its mission. Requirements define the essential attributes of the system. There are three types of requirements; performance requirements, constraints, and interface requirements.

- Performance requirement - specifies how well a function must be performed
- Constraint - limits or constrains the design solution; these typically come from laws; regulations; DOE Orders; codes and standards; previous design decisions; operating / maintenance experience; etc.
- Interface requirement - requirement imposed on one system by another

Performance requirements are related directly to functions and are quantitative requirements of system performance. They specify how well, how fast, how much, how far, how frequent, etc. functions must be performed. Performance requirements are usually directly measurable (e.g., miles per hour, gallons per minute, feet, minutes). Consequently, every function must have a minimum of one performance requirement associated with it. Performance requirements control the overall system design by providing specific parameters that must be met by the design.

B.1.3 Why Are Functions and Performance Requirements Important?

Functions and performance requirements are developed as input to the design effort and their development is a key step in supporting project planning and definition. The process of function and performance requirements development focuses on describing the necessary and sufficient set of requirements that meet the mission need. By defining functions and performance requirements, the system purpose is clearly defined.

Functions and performance requirements are the key design input because they specify what and how well something is to be done. Clearly defined functions and performance requirements also enable planning of design activities and can assist in establishing system optimization limits. Engineers/scientists can always improve on something. However, when the functions and performance requirements are met, continued improvements are not necessary and should be stopped. When the design input, free of design solutions, is provided to system designers, it allows the designers to do their job with the most freedom, and to design the system that best meets the mission need. The functions and performance requirements provide the baseline to evaluate proposed designs. Consider Figure B1, Function/Requirement/System Relationships.

Figure B1 illustrates the relationships between the functions, requirements, and system architecture. Performance requirements, constraints (design requirements), and interface requirements are included in the figure. Everything is built upon the system functions.

Performance requirements are allocated to functions. This relationship identifies how well the functions must be performed. Functions are allocated to the system

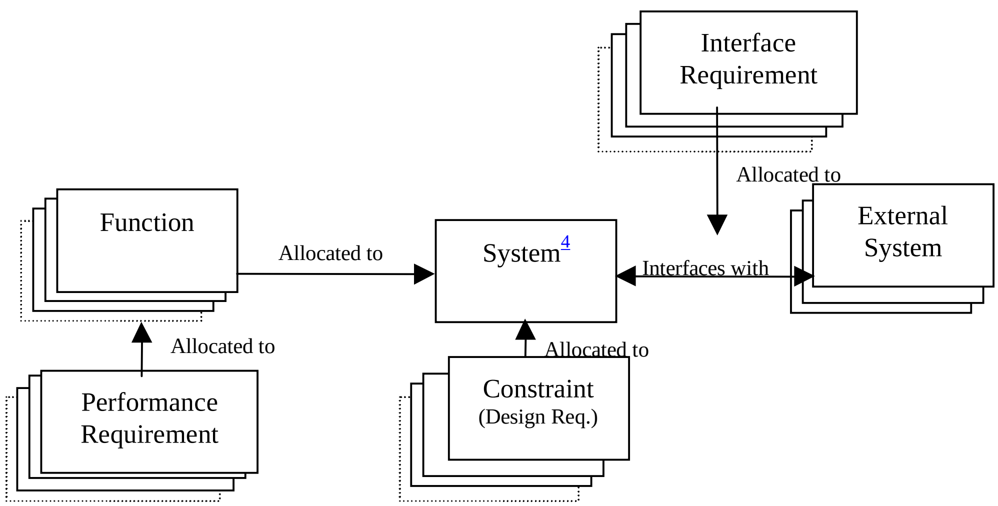


Figure B1. Function/Requirement/System Relationships

architecture. This relationship identifies what portion of the system architecture will perform the function. After the function to system allocation is made, the constraints can be completely identified and allocated to the system. That relationship indicates what constraints apply to what portions of the architecture. The figure also identifies the relationship between the system architecture, external system architectures, and the interface requirements. Interface requirements are identified and related to the interface between the systems.

The design process begins with identification of system functions and performance requirements. This indicates the importance of the function and performance requirements development process as the first step in preparing the design input on a task. Along with the functions and performance requirements, the known constraints and interface information (requirements and interfacing systems) are added as design input in order to more completely define the system. However, the system architecture must first be defined in order to completely specify the constraints and interfaces for a given layer of development (note that the physical architecture of the system is developed in layers and that each layer may have multiple levels within it.)

As an example, consider a function to "supply water" with performance requirements of a given pressure and flow rate. A constraint on the design may be known that requires water with given characteristics (e.g., domestic water versus service/process water). Based on the constraint requiring domestic water and the performance requirements of pressure and flow rate, the appropriate pipe codes for at least a portion of the system may be specified. However, for this example, two possible alternatives for supplying the water are 1) a holding tank system or 2) a connection to an existing header. Until the design selection has been made to utilize the holding tank system, for example, the selection of any pressure vessel codes for the holding tanks can't be made.

B.1.4 When is Function and Performance Requirements Development Performed?

The systems engineering process is iterative. The process begins with broad, task-related information lacking specifics and iterates toward increasingly detailed information. Each of the systems engineering process steps are performed at every layer of system development before proceeding to the next layer. The SE process steps are shown in Figure 2, the Systems Engineering Process Model.

Function and performance requirements development is performed during the Functions and Requirements Analysis and Allocation step (shaded in Figure 2). Function and performance requirements development is basically the process of converting the system mission analysis information into a well-defined, tangible set of actions (and associated requirements) the system must perform.

Figure 1 and the discussion in Section B.1.3 described in more detail how some of the elements and steps shown in Figure 2 are related.

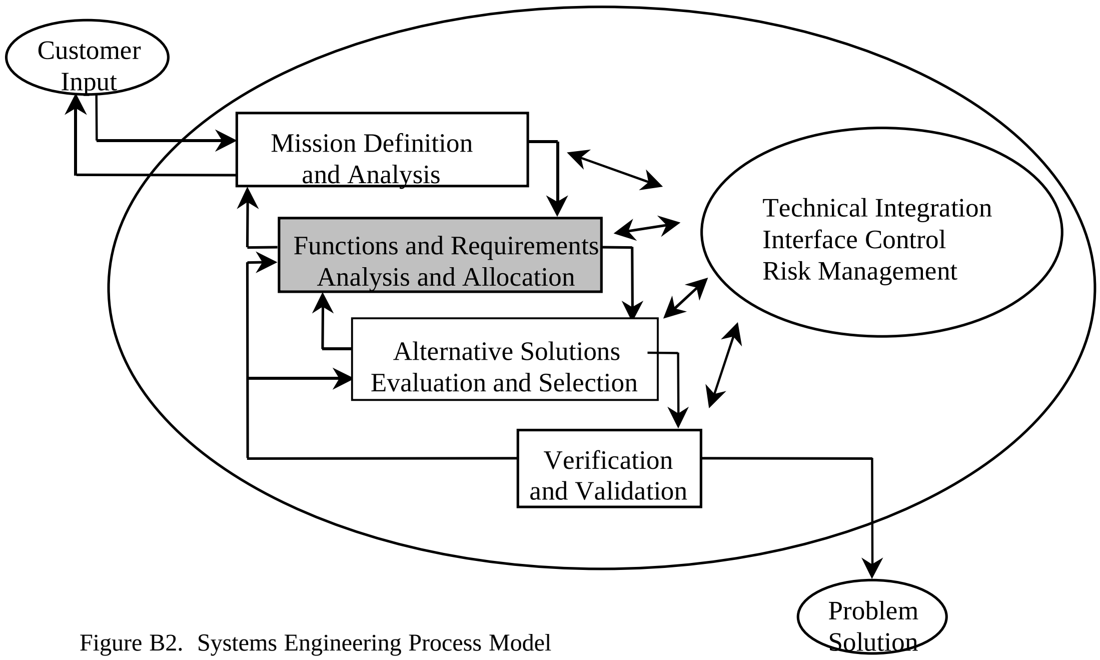


Figure B2. Systems Engineering Process Model

B.2.0 Function and Performance Requirements Development Process

Two general methods for functional development are presented in this section. The first method relies heavily on the identification of external interfaces. The external interfaces that cross the boundary of the system architecture are defined. The items crossing the system boundary are functionally traced through the system one at a time. The functions identified by tracing each item through the system, along with the functional interface information, are then combined to create a functional flow block diagram for the system.

The second method is driven by a hierarchical decomposition of upper-level functions. This hierarchically based method relies primarily on brainstorming by the functional development team as the means of identifying the lower level, more detailed functions that are required to perform the upper-level function being decomposed. Once the decomposition has been completed, the development team generates the functional flow block diagram and functional interface information.

Both of these methods are applied iteratively in conjunction with the other SE process steps. Each step in the SE process is completed at the most general layer of system development before moving down to layers with more and more detail.

A combination of these two methods is required at each layer in order to complete the functional development. Regardless of whether the functional development team begins with the first or second method presented in this guide, the other method needs to be applied in order to identify any holes or other problems. Table 1 and the discussion that follows provide a general comparison of the two methods.

The External Interface Method is more applicable as the starting point for functional analysis on an existing system or when several higher-level functions have been allocated to a system. This method is more easily applied when there are multiple functions at the upper level. This often occurs when working on existing systems because it's sometimes difficult to identify a single overriding function that is performed by an existing system. This method initially takes some of the focus off the upper-level functions and concentrates on the external interfaces. This method still requires that the lower-level functions decompose the upper-level functions of the system, but it becomes more of a test after the functions have been identified rather than the basis for the lower-level functions.

In contrast, the Functional Hierarchy Method places the majority of the focus on the upper-level functions. This method is more easily applied to a new system. The decomposition of the upper-level function generally results in no more than four or five functions being identified and a correspondingly simple flow diagram. The External Interface Method, on the other hand, tends to drive the functional analysis to a lower level of detail due to the tendency to get specific on interfaces. As a result, the External Interface Method better emphasizes system behavior and typically results in more complete functional flow block diagrams. The Functional Hierarchy Method makes it easier to stay at a higher level of detail when beginning a functional analysis for a new facility or system. Consequently, the more general functions that are developed with this method also allow for a simpler, cleaner allocation to system architecture. This can, correspondingly, result in making the development open to more alternatives and possibly provide a better solution.

External Interface Method	Functional Hierarchy Method
Lends itself to application on existing systems	Lends itself to application on new systems
Architecturally/physically based	Functionally based
Generally results in more functions and more detail for a given level	Generally results in fewer functions and less detail for a given level
More complicated allocation to physical components	Simpler allocation to physical components
Emphasizes system behavior and provides a complete picture on a single FFBD	Minimizes system behavior considerations due to multiple simple FFBDs
Doesn't guarantee all functions are identified, should be combined with Functional Hierarchy Method	Doesn't guarantee all functions are identified, should be combined with External Interface Method

Table 1. Function Development Process Comparison

With the Functional Hierarchy Method, each of the upper-level functions is decomposed and a separate functional flow block diagram is generated for each. This has the potential for not highlighting important functional interactions of an existing system, especially if the upper-level functions that have been identified are not very carefully considered. The External Interface Method generally results in functions from all of the upper-level functions being shown on one more complicated functional flow block diagram (similar to that of Figure A-8 in Attachment A). This facilitates a more thorough analysis of the functional interactions and can provide a more complete picture, although it can also lead to becoming bogged down in the details.

Often when the Functional Hierarchy Method is employed, the functional development team completes a functional decomposition for several levels of system development during one meeting or a series of meetings in a short time frame. This usually occurs without generating the accompanying functional flow block diagrams and N-squared diagrams or any of the other SE process steps. This is probably the biggest pitfall associated with employing this approach and should most certainly be avoided. As mentioned several times previously, EACH STEP OF THE SE PROCESS MUST BE COMPLETED AT EACH LAYER OF SYSTEM DEVELOPMENT.

Both methods have advantages and disadvantages and a quick application of "the other method" is required in order to double check results before moving on to the next step of the SE process. If the External Interface Method is applied to an existing system, apply the principles of the Functional Hierarchy Method to determine if the functional decomposition makes sense. Alternatively, when the Functional Hierarchy Method is applied, use the External Interface Method to determine if any holes exist in the functional decomposition.

B.2.1 Overview of External Interface Method

A summary of the External Interface Method presented in this guide can be found in Table 2, External Interface Method Summary. The table lists the process step and a brief description of the expected output from the step.

Process Step	Output
1-System Mission Analysis Review	Top level system functions and performance requirements
2-External Interface Identification	System external interface diagram
3-System Operational / Maintenance Concept Development	Narrative description of operational and maintenance concept, with system event list
4-Functional Sequence Development	System functional descriptions and simple functional flow block diagram with functional interfaces identified
5-Functional Sequence Integration	System functional descriptions and integrated, system functional flow block diagram with functional interfaces identified
6-Functional Hierarchy Generation	System functional hierarchy diagram
7-Performance Requirement Development	Performance requirement(s) for each function, with defendable basis

Table 2. External Interface Method Summary

The system mission analysis review involves simply gathering and becoming familiar with the output from the Mission Definition and Analysis step. The output from the Mission Definition and Analysis step is identified as: top level functions, top-level quantified performance requirements, initial risk assessment, external interfaces, and mission goals and objectives.

The external interface identification, as indicated above, should have been performed in the Mission Definition and Analysis step. Sometimes the external interfaces are identified during the mission analysis at a level that groups the items flowing across the interface at a level that is either too general or too detailed. In this case, this step involves adding some additional detail or aggregating the interface information. Otherwise, it is simply a review of the previously identified interfaces.

The system operational/maintenance concept development step is intended to initiate a discussion focused on the high-level vision associated with the system operation and maintenance. This step is highly conceptual and the descriptions produced at this point in the system development are likely to change, but these concepts lay the framework for the system behavior. This step forces the discussion and capturing of written concepts early so that all parties involved begin with a similar view.

The functional sequences are developed by identifying the functions that are performed by the system on items crossing the system boundary. This step involves identifying the functions that the system has to perform in order to transform the inputs to the system into the outputs from the system. This step results in a series of simple functional sequences.

The functional sequence integration step involves combining all of the simple functional sequences into one functional flow block diagram (FFBD). The system functional flow block diagram represents the system behavior, in its entirety, on one functional flow block diagram.

Following completion of the functional sequence integration, the system functional hierarchy diagram is completed. The functional hierarchy identifies the functional decomposition relationships.

The performance requirement development step results in at least one performance requirement being identified for each of the identified functions. The performance requirements must be quantified and have a defendable basis.

B.2.2 Overview of the Functional Hierarchy Method

A summary of the Functional Hierarchy Method presented in this guide can be found in Table 3, Functional Hierarchy Method Summary. The table lists the process step and a brief description of the expected output from the step.

Process Step	Output
1-System Mission Analysis Review	Top-level system functions and performance requirements
2-System Operational / Maintenance Concept Development	Narrative description of operational and maintenance concept, with system event list
3-Functional Decomposition	System functional descriptions and functional hierarchy diagram
4-Functional Flow Block Diagram Generation	System functional flow block diagram with functional interfaces identified
5-Performance Requirement Development	Performance requirement(s) for each function, with defendable basis

Table 3. Functional Hierarchy Method Summary

The system mission analysis review involves gathering and becoming familiar with the output from the Mission Definition and Analysis step. The Systems output from the Mission Definition and Analysis step is identified as: top level functions, top-level quantified performance requirements, initial risk assessment, external interfaces, and mission goals and objectives.

The system operational/maintenance concept development step is intended to initiate a discussion focused on the high-level vision associated with the system operation and maintenance. This step is highly conceptual and the descriptions produced at this point in the system development are likely to change, but these concepts lay the framework for the system behavior. This step forces the discussion and capturing of written concepts early so that all parties involved begin with a similar view.

The functional decomposition is developed by identifying those lower level functions that the system must perform in order to complete the upper level function(s). This step results in a functional hierarchy diagram.

The functional flow block diagram generation step involves identifying functional interfaces and capturing system behavior. The system functional flow block diagram and N^2 diagram or enhanced FFBD represents the system behavior.

The performance requirement development step results in at least one performance requirement being identified for each of the identified functions. The performance requirements must be quantified and have a defendable basis.

B.2.3 Performance Requirement Development

B.2.3.1 Function/Performance Requirement Relationship

As described in Section B.1.3, performance requirements are related directly to functions and are quantitative requirements of system performance. They specify how well, how fast, how much, how far, how frequent, etc. functions must be performed. Every function must have at least one performance requirement, although there are typically several, and the relationship between the functions and their respective performance requirements must be maintained. It should be very clear what performance requirements are associated with what functions. A simple numbering system may communicate this relationship.

An example numbering system is shown below. This sample numbering system makes use of a letter to differentiate the functions and performance requirements, "F" for function and "R" for performance requirement. The relationship between the performance requirement and its respective function is indicated by converting the "F" to an "R" and adding ".*x*."

F.1 "Description of function number 1"

- R.1.1 "Number 1 performance requirement statement"
- R.1.2 "Number 2 performance requirement statement"
- R.1.3 "Number 3 performance requirement statement"

F.2 "Description of function number 2"

- R.2.1 "Number 1 performance requirement statement"
- R.2.2 "Number 2 performance requirement statement"

Just as functions are decomposed into greater levels of detail, the accompanying performance requirements must be decomposed. Consider the example illustrated in Figure B3.

The upper part of Figure B3 illustrates the functional decomposition where upper-level function 1 is decomposed into three subfunctions, functions 1.1, 1.2, and

1.3. Also shown on Figure B3, are the accompanying performance requirements that are related to the same measure of performance. For example, upper-level performance requirement 1-1 may be a requirement limiting the total time allowed to perform upper-level function 1. The lower part of Figure B3 illustrates that the upper-level performance requirement 1-1 can also be decomposed such that the performance of the subfunctions to function 1-1 must be allocated to maintain the upper-level performance.

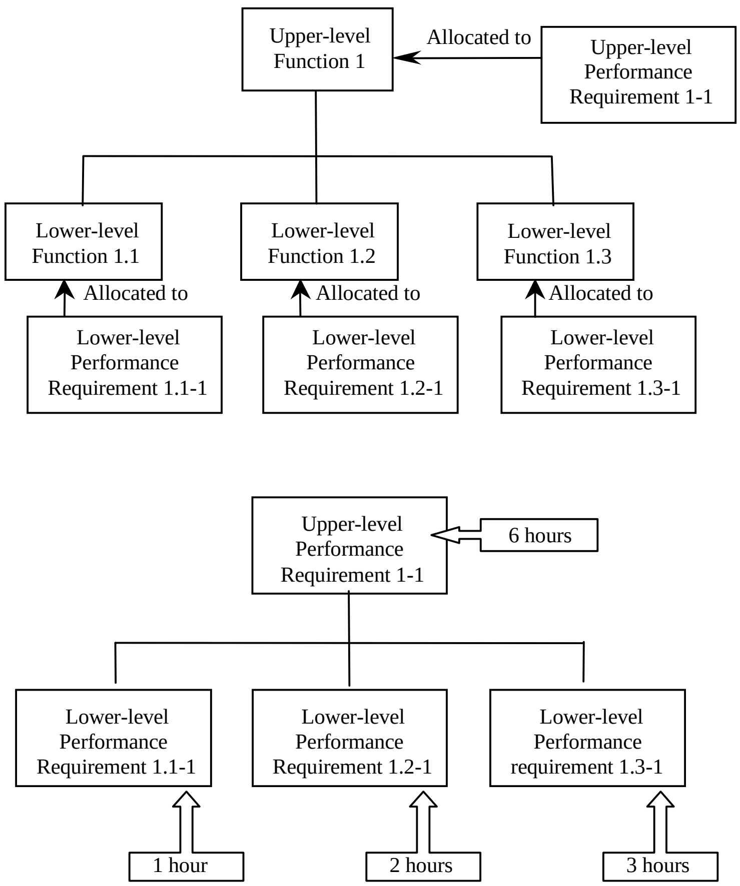


Figure B3. Example Performance Requirement Decomposition

For example, if upper-level performance requirement 1-1 is a time requirement such that function 1-1 must be performed in a maximum time of 6 hours, then the time for each of the subfunctions to be performed may be split into a maximum of 1, 2, and 3 hours for a total of 6 hours.

The above discussion on the decomposition of performance requirements does not mean to imply in any way that the subfunction performance requirements must be directly decomposed from an upper-level performance requirement. They must, however, still support the performance requirements of the upper-level function.

B.2.3.2 Developing Good (Performance) Requirements

This section provides guidelines for developing and writing good performance requirements. The guidelines are equally applicable to constraint and interface requirement development. Therefore, the more general “requirement” is referred to in the remainder of this section rather than the more specific requirement-type “performance requirement”.

A list of key attributes of good requirements is provided below. A discussion of each of the attributes follows the list.

Key attribute list:

- Clear/concise, single-sentence format
- Necessary
- Attainable
- Verifiable
- Shall statements
- Defendable basis
- Implementation free
- Appropriate level
- Tolerances specified
- Positive format.

Clear concise, single-sentence format

Requirements should be written as a single sentence. This means that every requirement must be a standalone sentence with one requirement, stated clearly, simply, and concisely. One thought per requirement (per sentence) that ideally can’t be misunderstood. Complex sentences with multiple clauses should be avoided. Each requirement should also be uniquely identified. Individual, uniquely identified requirement statements are necessary for traceability from higher level requirements, traceability to system functions or architecture, and for possible revisions.

Necessary

Every requirement has to be necessary. A requirement may be written clearly and concisely in a single, positive sentence as a "shall" statement, it may be free of design solutions, it may be quantified and specify tolerances, it may be written at the appropriate level, but if it's not necessary, it's still a bad requirement. This attribute of a requirement ties directly back to the basis for the requirement and illustrates the need to question and provide a defendable basis for every requirement. Asking "What is the worst thing that could happen if this requirement is not included?" is another good test for the necessity of a requirement. This question often results in identifying the requirement as being "nice to have" but not really a necessity and can often result in the requirement being converted to a goal.

Attainable

Every requirement must be attainable. As described above in the discussion for the necessity of each requirement, a requirement may possess all of the attributes that make it a good requirement, but if it's unattainable, it's still a bad requirement. A requirement may be unattainable for a number of reasons including technology, budget, schedule, or a higher-level requirement. If there are questions about the attainability of a requirement, feasibility studies may be required. Unattainable requirements may also be converted into goals.

Verifiable

Requirements should be verifiable. Every requirement must be written in a manner in which compliance can be demonstrated. Most often this becomes a problem when words like "maximize," "minimize," "to the maximum (minimum) extent possible," "user-friendly," "optimum," "sufficient," "adequate," "low," or "high" are used. Words specifying timing often create problems also. "Simultaneously," "quick," or "rapidly" mean different things to different people. Is simultaneous within 1 millisecond, 1 second, or longer? A helpful technique to employ when writing requirements is to ask the question, "How can this requirement be verified?" Requirements must be quantitative not qualitative.

A few more words or phrases that will cause problems when writing requirements are: "support," "and/or," "etc.," and "but not limited to." "Support" causes problems because it typically shows up in a requirement similar to this, "System *XYZ* shall support error recovery." The problem with this requirement is that it is open-ended and can't be verified. If there are certain functions that System *XYZ* must perform in order to support error recovery, then specifically list each function as a requirement with a defendable basis. Otherwise, this "requirement" may be converted into a goal that would feed into alternative studies as a decision criterion.

The problem with "and/or" isn't really related to verification of the requirement but rather in realizing what it means when it is used. If "and/or" is used in a requirement statement where "*A* or *B*" is to be provided, then the requirement has been met if either A, B, or both A and B are provided. This isn't a problem unless both A and B are required. Therefore, special caution is to be exercised if "and/or" is used.

When used in requirement statements, "etc." and "but not limited to" result in requirements that can't be verified, are surrounded by questions, and tend to leave things open to interpretation. They're most often used in a list[1] and usually indicate that the author thinks there may be other items that haven't been included. That may be so. However, by adding this element of the unknown in a requirement statement, the entire statement becomes unverifiable. Including "etc." and "but not limited to" won't cause additional requirements to be met should they happen to be identified at a later time, although including "etc." and "but not limited to" may result in none of them being provided. As a result, these terms should be avoided. Just provide requirements for the items that are known and should additional items be identified later, revise the requirements.

Shall statements

Requirements must be written as "shall" statements. Requirements are not to use the word "should". Requirements are things that must be met by the system. If a potential design solution doesn't meet a requirement, it is no longer considered a design solution without rework (either to a requirement or to the potential solution).

"Should" is typically used when writing goals. A goal is to be clearly differentiated from a requirement. A goal is something that is to be strived for given other requirements. Goals are direct input for decision criteria in alternative analyses and trade studies. Goals provide a basis for evaluating potential design solutions. Additionally, "will" refers to statements of fact and must not be used when writing requirements.

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[1] Note that use of lists is not recommended. As noted in this Section, each requirement should be uniquely identified. When items are included in a list, there is usually not a unique identifier for each separate item. One exception where this may be acceptable, is the case where each item has the same basis and will be verified by the same test. This rarely happens and, as such, the use of lists is discouraged.

Defendable basis

Every requirement must have a defendable basis. The basis includes the supporting rationale for the requirement. The basis references any data, trade studies, or other sources for the requirement. Any assumptions made that resulted in the requirement and the associated logic should also be provided in the basis. The basis is typically included in an appendix with design input documents. This is an acceptable format to enable easier reading after review and approval of the document. However, it is recommended that, at least for any early drafts, the basis be included with the requirement statement. This facilitates the review by eliminating any flipping back and forth between an appendix and the body of the document, emphasizes the importance of the basis, and helps to ensure the basis is indeed reviewed.

Implementation free

Requirements must state what the system does rather than how the system must do it. A common pitfall when writing requirements is to specify a design solution rather than the requirement behind it[2]. To avoid this problem ask, "Why is this requirement needed?" If that question doesn't take you back a level, then the requirement is probably stating the need rather than the implementation. Asking this question commonly results in a number of separate requirements replacing the original "design solution" requirement statement. This question also helps to identify the basis for the requirement once the design implementation has been removed. Other than the obvious problem with specifying a design solution, that of potentially eliminating a better solution, there is a potentially more dangerous problem. The second more dangerous problem is that of assuming that specifying a design solution covers your actual needs. This may result in a product delivered as specified that does not deliver what is required. Another problem associated with specifying a design solution in a requirement statement comes about when the verification is performed. If there is a verification that the "design solution" requirement has been met, the only thing that has been verified is that the system has a design, not that the design works. This effectively results in eliminating any value added from verification activities.

[2] Requirements are often generated in order to fill a perceived hole in a requirements document. This common practice tends to lead to the specification of design solutions rather than requirements and great caution should, therefore, be exercised if this practice is undertaken.

- Example: Consider the following requirement statement written into an aircraft specification—"The aircraft shall have three engines." This is clearly a requirement specifying a design solution. When the question "Why do you need three engines?" is asked, the real requirement that the aircraft shall be able to operate with an engine failure would become apparent. It is also easily seen that requiring three engines rather than requiring that the aircraft operate with an engine failure could result in the real requirement not being met.

- Another common example of stating implementation is demonstrated with the following requirement—"The Container Transport Subsystem shall control position to within ±0.5 inches in three dimensions." This example requirement indirectly constrains the system design by specifying a subsystem. One last example requirement stating implementation rather than the real need is given by the requirement, "A database shall be provided." When the question "Why is this requirement needed?" is answered, the following 'real' requirements are given; "The capability for traceability between items shall be provided," "The capability to add attributes to items shall be provided," "The ability to sort items shall be provided."

Appropriate level

An additional caution related to including implementation in the requirements is specifying requirements at an appropriate level. Recall that the SE process is iterative, it runs through each of the basic SE process steps at a given layer. After a layer is completed, the next lower layer of development begins. When specifying requirements, it is important to keep in mind what stage, or layer, of development the system is in. If the requirements are being developed at the system layer, requirements should not be included for individual components. Specifying lower-level requirements at the upper levels of system development tend to overly constrain the design and are an indirect way of specifying implementation. As a general rule, if the requirement does not apply completely to the scope, or piece, of the system that you are currently working on, it should instead be included at a lower layer. In other words, requirements should be specified at a layer where they affect all the parts below that layer. This is a rule that intends to place the focus on the bigger picture before moving into the details.

- As an example, think about developing requirements for a facility in a FDD. Requirements that are specific to an individual component or system should not be included in the FDD. Instead, the requirement should be specified in the appropriate SDD (in the component section, if it's applicable to an individual component as opposed to the entire system).[3]

Tolerances specified

Requirement tolerances should be specified. Requirements written without tolerances can quickly lead to increased costs, both from a product delivered without the required tolerances as well as those with unnecessarily tight tolerances. It's pretty obvious what kind of problems you can get into when close tolerances are required and aren't provided. But the opposite can be true as well. For example, consider the requirement to "...provide a lifting capacity of 1,000 lbs." Imagine, for this example, that other requirements restrict this lifting function to a forklift and that there are no readily available commercial (and theoretically cheaper) forklifts available with a lifting capacity of less than 2,500 lbs. The requirement specifying a lifting capacity of 1,000 lbs may result in a special-purpose design for performing the lifting function because it is unclear whether a 2,500 lb. capacity forklift is acceptable. If the requirement were written instead as "...provide a minimum lifting capacity of 1,000 lbs." then it is clear that the 2,500 lb. capacity forklift would be acceptable.

Positive format

Requirements should be written in a positive format. Requirements written negatively are, at a minimum, difficult to read and understand, and can sometimes be impossible to verify.

- Example: "The function shall not be completed in more than 10 seconds." As written, this example is difficult to read and understand. This requirement should be written as "The function shall be completed in less than 10 seconds." Consider another example, "The system shall not allow failures due to operator input." This is an example of a typical "shall not" requirement that is impossible to completely verify. This type of requirement statement should be avoided.

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[3] This often causes problems for both the customer and system development teams because of a fear that a requirement will be lost. However, if the requirements are captured at an inappropriately high layer, they end up being repeated at the lower layer, or they get changed, or they disappear altogether due to development at the upper layer. If a requirement gets repeated in a lower-layer requirements document, there are duplicate requirements that must be managed. If the requirement is changed or disappears, this forces a revision to the upper-layer requirements document. The use of a holding bin for requirements that come up but really don't belong at the level where work is being performed is suggested as an effective tool for avoiding this situation.

B.3.0 Suggested Reading List

Writing Good Requirements, Hooks, I. (1994), Proceedings of the Third International Symposium of the NCOSE.

Systems Engineering and Analysis, Blanchard, B.S., and Fabrycky, W.J.(1990), Prentice Hall, Inc.

System Requirements Analysis, Grady, J.O. (1993), New York: McGraw Hill, Inc.

Discovering System Requirements, A. Terry Bahill and Frank F. Dean, located at http://www.sie.arizona.edu/sysengr/requirements/index.html.

Characteristics of Good Requirements, Pradip Kar and Michelle Bailey, Proceeding of the Sixth Annual International Symposium of the International Council on Systems Engineering, July 7-11, Boston, MA, located at http://www.incose.org/workgrps/rwg/goodreqs.html.

Guide for Managing and Writing Requirements, Hooks, I., 1994.

Appendix C

ALTERNATIVE STUDIES and VALUE ENGINEERING

C.1.0 Introduction

C.1.1 Purpose

The purpose of this guide is to describe the steps, tools, and techniques involved in the Alternative Study (aka Trade Study) Process (including value engineering) as integrated into the application of the Systems Engineering Process for DOE activities. This guide is to be used for selecting the optimum, most cost-effective alternatives that meet an activity's functions and requirements. While the major application of alternative studies (in particular value engineering) is in design and construction projects, these activity alternatives can be in other areas such as operations, maintenance, administrative processes, etc.

C.1.2 Types of Studies and Distinctions

There are numerous methods available for evaluation of an activity and selection of the best method to accomplish the activity. Such tools include cost-time profile evaluations and process improvement analyses for ongoing operations and processes, benchmarking for new ventures, carbon copy facility design for new constructions to eliminate variability and capitalize on lessons learned, use of engineering judgment, etc. This guidance document covers the alternative study method, including a specific type of alternative study – namely, value engineering - and the recommended methodology for application.

C.1.2.1 What is an Alternative Study?

An alternative study is a tool used to select from two or more options available to meet a specific function. Alternative studies encompass analysis of functions and are directed at optimizing performance, reliability, quality, safety and life-cycle cost of a product or activity. Alternative studies include the following steps:

- Identification of the function(s) to be met and the defined project requirements
- Identification of alternatives that perform the function(s)
- Determination of viability of the alternatives to satisfy requirements
- Establishment and weighting of criteria against which to evaluate alternatives

- Evaluation of alternatives against the selected criteria
- Selection of a preferred alternative.

An optional step, employed when no alternative is clearly preferred based on the results of the alternative study, is a sensitivity analysis.

Attachment 1 provides a flow chart of the alternative study process.

Alternative studies can be conducted at one of three levels:

- A simple, informal alternative evaluation. This process is suggested where no alternative poses a significant risk to the success of the activity. One alternative is clearly superior to all other choices and/or there are no discernible criteria for selecting among alternatives. An informal memo may be used to document the selection of the alternative and basis for the selection.
- An informal alternative study. This study follows the same process as a formal alternative study, but less rigor is applied to the conduct of the study and documentation of the results. This process is suggested where the risk to the activity, based upon the selection of any of the alternatives, is moderate, the activity is not complex, and discernible criteria can be identified. The study may be documented in a memo, incorporated in other documentation for the activity, or presented in a formal report.
- A formal alternative study. This process follows a structured approach for comparison of alternatives. The process uses formal analysis and is based on a set of weighted decision criteria. This process should always be applied to line-item projects and other complex activities or where the risk to the activity, based on the alternative selection, is relatively high. A formal alternative study is documented in a formal report.

C.1.2.2 What is a Value Engineering Study?

A value engineering study is a specific type of formal alternative study that follows a prescribed methodology or job plan. In addition to optimizing performance, reliability, quality, safety, and life-cycle cost, a value engineering study is specifically intended to identify solutions that improve upon these features relative to an established baseline. Value engineering studies are led by an individual trained in value engineering and conducted interactively by a team, selected jointly by the manager of the activity being studied and a VE-trained individual, who are independent of the work performed on the program, project or activity. While an alternative study can follow the defined methodology for a value engineering study, all value engineering studies must complete certain steps to be considered as value engineering studies.

The steps followed in conducting value engineering studies are:

Information Gathering – The step in which the value engineering team collects information relative to the activity. Most often, cognizant activity personnel initiate the information gathering process with a technical presentation several weeks in advance of the interactive study session. This step includes generation of a Functional Analysis System Technique (FAST) diagram by the value engineering team and culminates in identification of those functions which, by design, may have a Cost/Worth ratio higher than that necessary to meet requirements. Attachment 2 provides details on completion of a FAST diagram and Attachment 3 discusses Cost/Worth ratios.

Creativity or Speculation – The process of generating alternative potential methods for accomplishing a given function.

Analysis and Judgment – The process of evaluating identified alternatives. This step includes development and weighting of criteria against which alternatives can be measured, and determination of the relative merit of an alternative against those criteria for the purpose of selecting the optimum alternative(s).

Development – The process of defining details associated with the selected alternative(s). These details include a description of the alternative and a comparative analysis between the selected alternative and the baseline, including a cost estimate for the selected and baseline alternatives.

Recommendation/Presentation – Identification to decision makers of recommendations resulting from the value engineering study.

As with other alternative studies, a sensitivity analysis is often included in the analysis phase to assure proper selection of a preferred alternative.

C.1.3 When to Perform an Alternative Study

C.1.3.1 Scope

All decisions made during the conduct of an activity include an alternative evaluation in some form. However, not all evaluations of alternatives require a documented alternative study. The depth and formality of the alternative study are dependent upon the complexity of the decision being made (see section C.1.2.1

above). A documented alternative study should be conducted when criteria can be established that discriminate among potential alternatives, especially when it is unclear if or how all alternatives meet the identified functions, or when there is a significant difference among the alternatives in terms of risk to the activity. A formal alternative study is selected when the activity is complex or risks are considered high.

C.1.3.2 Timing

There is no specific timing recommended for conducting an alternative study that covers all cases. Since all decisions involve an alternative evaluation, alternative studies are conducted as needed throughout the activity.

C.1.4 When to Perform a Value Engineering Study

C.1.4.1 Scope

A value engineering study is intended to apply a level of independence to an activity and the selection of steps to complete this activity. Value engineering is conducted when numerous functions are assigned to the activity and their integration and interrelationships are complex, when significant financial resources are required to support the activity, when criteria selection and weighting are subject to interpretation, or when the evaluation of alternatives could be implemented and interpreted in several ways. In general this applies to all line-item projects.

C.1.4.2 Timing

Unlike other alternative studies, value engineering studies begin with a baseline approach or design. In addition, since a value engineering study can result in recommending some significant changes in project direction, it is recommended that the study be conducted before significant effort has been devoted to design detail. For these reasons, the optimum timing for a value engineering study is between the completion of the conceptual design and the initiation of the detailed design. Attachment 4 illustrates the potential for realizing benefits from a value engineering study at various phases of the project cycle.

C.2.0 Methodology and Tools

There are a number of different methods available to facilitate conduct of a value engineering or alternative study. Several of these are discussed in the following sections.

C.2.1 Study Initiation and Information Gathering

Alternative studies are generally initiated during the normal course of work for new constructions, modifications, and projects any time a decision is required. Often a conceptual design report identifies a number of critical areas where the need for documented alternative studies is envisioned. For other activities, initiation of an alternative study is based upon a perceived need on the part of users to evaluate various ways to meet their requirements.

Because alternative study participation is intended to rely on individuals involved in and knowledgeable of the activity under study, the need to provide an orientation meeting to initiate the study is limited. Generally, only individuals brought in as study facilitators or subject matter experts require background information in advance of the study.

Because a Value Engineering Study Team is expected to be independent of the activity being studied, the planning needs associated with value engineering studies differ somewhat from those of other alternative studies. Prior to initiating the value engineering interactive study, the Study Team must be provided with information regarding the activity. This information is to include the technical information regarding the design and/or operation, as well as a cost estimate of the design, maintenance, and operations. For efficiency, personnel expert in the activity being studied (e.g., Project/Design Teams, Maintenance/Operations personnel, etc.) should provide this information to the Study Team approximately two weeks in advance of the study.

C.2.1.1 Functions and Function Analysis

The first step in an alternative study is function identification and analysis. In the majority of alternative studies, this step involves a list of one or more functions required to meet user needs. Sometimes these functions are decomposed to greater levels of detail, but generally are limited in scope to a defined study topic (e.g., system design alternatives, component selections, etc.). While there is no difference in the function analysis process between informal and formal alternative studies, informal alternative studies generally include fewer systems and components and consequently fewer functions due to the lower level of risk. In value engineering studies this step culminates in a Function Analysis System Technique (FAST) diagram (see Attachment 2). While function definition is a critical part of the systems engineering process, FAST diagramming differs in the following ways: FAST diagram preparation is done independent of the design effort; FAST diagrams are done by a team of individuals who did not participate in the design decisions to date; FAST diagrams follow a “HOW-WHY” logic;

FAST diagrams are constructed to a level of detail commensurate with the needs of the study, not to the level of detail required to complete design work.

Unlike function generation and decomposition in design, where functions and requirements are defined first and design solutions that meet these functions and requirements selected next, FAST diagrams are based on the functions of the structures, systems, and components already identified in the design.

C.2.1.2 Cost/Worth Evaluations

The cost/worth evaluation is a comparison by the Study Team of the lowest cost available to meet a given function (the "worth" of the function) against the actual identified cost for the structure, system, and/or components selected to meet this function (the "cost" of the function). Note that cost/worth ratios have little meaning if there is no proposed design or if a cost estimate has not been prepared for the proposed design. Thus, cost/worth ratios are most commonly associated with value engineering studies, that rely on the existence of a baseline approach than with other alternative studies.

Some caution is required in developing cost/worth ratios. Many items, especially structures, systems, and complex components, are designed to accomplish multiple functions. Cost estimates, however, are usually available no lower than the component level. Thus the cost of a specific function is only a part of the cost of the component. The Team must judge what portion of the component cost is attributable to the specific function. This value is often, at best, a judgment call on the part of the Team. Similarly, the worth of a function is the Team's best guess of the least expensive method available to meet the function.

Often it is sufficient for the purposes of a value engineering study to identify that the cost/worth ratio is ">>1," ">1," "=1," or, in some cases, "<1." Functions with higher cost/worth ratios are the prime targets for value improvement.

C.2.2 Generation of Alternatives: Speculation

Generation of alternatives is usually done through Team brainstorming. In many alternative studies a list of alternatives to be considered is identified outside the interactive Team setting, generally as a result of initial design considerations or by user (facility) or DOE prescription. As with function analysis, there is no difference in the process for generating alternatives between informal and formal alternative studies, although informal alternative studies generally have fewer functions, thus a lesser scope, resulting in fewer applications of the process (although not particularly in identification of fewer alternatives for each function identified). In value engineering, alternative generation is always done as a part of the interactive Team setting.

In Team brainstorming, high-cost/low-worth functions are first identified. The Study Team spontaneously produces various ideas on how to perform the identified function. Creative, divergent thinking is essential in this step. No ideas are to be critiqued at this stage and all ideas are recorded. Critical comments at this point tend to inhibit the flow of ideas. Furthermore, even frivolous suggestions can result in successful recommendations. For example, to meet a certain function a Team member might say "Let Superman squeeze it". While this may seem absurd, it could lead to a successful suggestion of using pressure, or a pressurized system, to perform a function when temperature control was previously used.

C.2.3 Evaluating Alternatives: Analysis and Judgment

Often the speculation phase results in one or both of the following: a number of infeasible alternatives, and a number of mutually exclusive alternatives. In the analysis phase, the Study Team must evaluate alternatives for both feasibility and selection of the best alternative from among several. Alternatives are evaluated for feasibility by ensuring first that they can perform the required functions and, second, that they meet the stated requirements. If the alternative fails either of these tests, it is eliminated or revised to perform the functions and meet the requirements. The best alternative is selected by establishing criteria against which to measure the various alternatives, choosing the relative importance of these criteria (i.e., weighting the criteria), and measuring the alternatives against the weighted criteria. These steps are discussed below.

C.2.3.1 Selecting Criteria

- Short List of Criteria

  Generally, once a list of alternatives has been developed, there are an extensive number of choices for meeting the functions identified. At this point it may be prudent to narrow this list to a manageable number. To do this a "Short List" of decision criteria may be employed. The short list identifies criteria that often represent "GO/NO GO" factors, as identified by activity requirements such as technological feasibility or the capability to produce a given quantity per unit time. In this case, alternatives that can not be designed to meet the requirements of the project are eliminated. Caution must be exercised in eliminating alternatives using GO/NO GO criteria so as not to eliminate alternatives that could be made viable. For example, if production rate requirements are 1,000 tons per year, based upon written requirements, any alternative producing 999 tons per year or less is eliminated. Users must be sure that requirements do not have a margin that includes the capabilities of the given alternative or that can not be legitimately modified to allow inclusion of the alternative.

► Decision Criteria

Criteria selection ultimately determines the alternative choice. Identification of criteria can be a simple task for a Study Team or it can be quite complex with numerous decisions included in the selection. Care must be taken to ensure that the criteria selected allow for discrimination among alternatives, i.e., if the color of all alternatives is the same or the user is indifferent to the color selection, then color is not a criteria. Although no requirements exist relating the quantity or type of criteria to the depth of the alternative study, criteria are typically selected that are commensurate with the level of risk associated with the activity being studied. Thus, informal alternative studies, which are expected to have a lower associated risk, usually have fewer, less complex criteria than formal alternative studies. Alternative performance must be capable of being measured or estimated for each of the decision criteria selected. This may be more involved for formal alternative studies, but must be commensurate with the level of effort applied to the study and the phase of development of the alternatives. For example, if alternatives are currently in the preconceptual phase of development and a decision criteria is selected as “maximizing performance y”, the effort required to estimate how the alternatives score on the criteria shouldn’t require a 3-year research and development program.

When an alternative study is being performed on a project, the project’s mission analysis should be the primary source for generating decision criteria. These criteria should be based on the project goals, objectives, requirements, and DOE and other stakeholder values.

Decision criteria should:

— Differentiate between alternatives

— Relate to project goals, objectives, and values of DOE and other stakeholders

— Be reasonably measurable or estimable

— Be independent of each other

— Be well understood by all decision makers.

There are several methods available to facilitate criteria selection. The first method is team brainstorming. In this approach all Team members spontaneously voice their opinion of criteria and all opinions are recorded. This method has the advantage of allowing all Team members to identify their ideas in an impromptu manner, minimizing prejudgment. The disadvantage of this method is that quieter members may never express their opinions.

A second method is round robin. In this approach, Team members are individually asked for their input of criteria. Again, all inputs are recorded. This method has the advantage of soliciting input from all Team members. However, it provides members an opportunity to prejudge what they are thinking and tends to thwart creativity.

A third method is reverse direction criteria development. In this approach, Team members consider some alternatives available, identify differences between these alternatives and develop criteria that reflect these differences. This technique is most useful when the viable alternatives, inclusive of their "pros" and "cons," are well known.

Because the criteria selection process relies heavily on human judgment, criteria development is done manually (i.e., without the aid of computer applications). However, a predefined set of criteria may be provided from external sources such as end-users, stakeholders and decision-makers, for incorporation into the final set. Input from the decision makers is essential to the development of the criteria set.

Once a full set of criteria has been established, these criteria can be modeled into a hierarchical parent-child relationship. Attachment 6 provides an example of this modeling process. Although application of this modeling is not restricted, it is more commonly useful with complex, high-risk decisions. Thus, this is generally applied to formal, but not informal, alternative studies. Hierarchical modeling of criteria facilitates both establishment of criteria weights and evaluation of alternatives against the criteria (see Sections 2.3.2 and 2.3.3). Duplicate criteria, or criteria that do not discern among the alternatives, should be eliminated.

C.2.3.2 Criteria Weighting

Although weighting of identified criteria is not required for all alternative selection processes (see Section 2.3.3), in complex decisions it is difficult to justify a single solution without consideration of the relative importance of the criteria established for making the decision.

Criteria weighting can be accomplished in several different ways:

- Direct decision and input of constant values for criteria weights
- Weight Ratios and Analytic Hierarchy Process
- Partial Weight Ratios
- Weight computation through ordering importance
- Weight computation based on "swing weights"
- Weight computation through tradeoffs of alternatives.

Each of these methods is described below:

Direct Decision and Input of Constant Values for Criteria Weights

The simplest way to weight criteria is through direct input of criteria weights. These weighted values predominantly come directly from decision makers, are established through expert judgment, or a combination of these. In this method, once the criteria have been selected, decision makers/experts decide how important each criterion is as a percentage of unity. Each criterion is given a relative score of between 0 and 1 (or 100%), depending upon its importance in selecting an alternative from among several. All criteria receive weights, with the total of these weights being 1 (or 100%). This method does have noted disadvantages; it can be difficult to reach Team consensus using this method. Furthermore, the method can introduce additional bias into the judgments over those introduced by other weighting methods.

Weight Ratios and Analytic Hierarchy Process

Another method for weighting criteria is the weight ratio (WR) methodology. WR methodology uses pair-wise ranking and "relative value" methodology to weight criteria. Each criterion is compared to each of the other criterion one set at a time. In comparing the criteria sets, Team members decide which of the two criteria is a more important factor in selecting an alternative and by how much.

The WR process can be completed either manually or via the use of various computer software tools available. In the simplified manual method, Team members collectively agree on which criterion in a given pair is more important and on the value for this relative importance. The scale for "how much" is numeric and is determined by the Team, although scales of one to five and one to ten are well recognized. In the latter case, one represents equal importance of the criterion and ten represents an order of magnitude difference between the two criteria.

Once established, this relative value score is summed for each criterion and is then either normalized to a scale of 0 to 10 or converted to a percentage, with the total of all scores being 100%. Attachment 7 provides a template and example of manually generated criteria ranking.

Advantages of simplified manual pair-wise comparisons are that, for a small number of criteria, it can be completed quickly during the interactive session. Disadvantages of this method are that one of the identified criteria should always go to a score of "0," thereby eliminating its influence on the decision. Consistency checks must be done separately (i.e., if A>B and B>C then either A>C or A>>C should be true). With larger numbers of criteria, total consistency is difficult to achieve and very difficult to check.

The Analytic Hierarchy Process (AHP) uses a specialized application of the WR methodology. In AHP, again individual criteria are compared one set at a time. In this comparison, Team members either collectively agree on which criterion is the more important and by how much, or individual members "vote" on these comparisons. In AHP, a criteria scoring range of one to nine is used. When individual voting is used, a single final score is established by using the geometric mean of the individual scores.

Equation Figure

The geometric mean is defined by:

s_i = individual score of a pair-wise comparison;

GM = geometric mean

For this application, the geometric mean is simply the n^{th} root of the product of n individual scores. Its value may be demonstrated for cases where one or more scores are widely dispersed from the rest. For example, in the set [1 2 3 9], the average, or arithmetic mean, is 3.75, while the geometric mean is 2.711. In this case, the arithmetic mean is greater than 75% of the individual elements. By using a geometric mean, the impact of widely varying perceptions on the relative importance of criteria is minimized. AHP then proceeds by using matrix mathematics and the eigenvector solution to establish criteria weights.

An advantage to AHP is that in AHP all criteria receive a score - i.e., if criterion A is 4 times more important than criterion B, then criterion B is ¼ as important as criterion A. Both numbers are used in the calculations. Thus, no criterion weight becomes zero, as with the simplified WR method.

As with the simplified application of WR, criteria weighting using the AHP methodology can be performed manually. Attachment 8 provides detailed instructions for establishing the weighting matrix and the use of the eigenvector solution to determine criteria weights. It is recommended, however, that if manual application is desired, the simplified WR methodology be employed.

Several software tools are available for automated implementation of WR methodology. Among them, the software tools Expert Choice (ECPro®) and Logical Decisions®, both of which apply AHP, are comparable and are relatively easy to use. An advantage of software-support use of AHP is an internal consistency check of the value comparisons.

Partial Weight Ratio

The partial weight ratio method utilizes pairwise comparisons as in the AHP process except that only enough pairwise comparisons are completed to ensure that each criterion has been included at least once. Because this method relies on an abbreviated set of criterion comparisons, no manual method is presented. This process is, however, supported through the Logical Decisions® software tool. An advantage of this method is that it is somewhat quicker to implement than AHP and can be utilized when evaluation Team members are uncomfortable comparing certain criteria. However, a disadvantage is that without all pairwise comparisons, a consistency check of inputs is not possible.

Weight Computation Through Ordering Importance

In the weight computation through ordering importance method, Team members define an alternative with the least preferred level of acceptability against all criteria. Team members then select the one criterion they would choose to improve, given this choice. This criterion becomes the most important criterion. The process continues until all criteria have been ranked. This method offers an advantage when comparison of criteria on a one-to-one basis is difficult. A disadvantage of this method is that criteria ranking is established on a mathematical interpretation of "preferred" criterion. Thus all weights are established on a binomial selection process rather than a relative value process.

Since success of this method is based upon a mathematical relationship established between "preferred" and "next preferred," etc. criteria, it is recommended that this method, like weight computation, be utilized through available software. Logical Decisions supports this process.

Weight Computation Based on Swing Weights

Weight computation based on "swing weights" is a combination of ordering preference and direct decision and input. In this method, as with ordering preference, Team members define an alternative with the least preferred level of acceptability against all criteria, then select the one criterion that they would choose to improve. This criterion is then given a "swing weight" of 100. Team members then similarly select the next criterion and determine the relative importance of "swinging" it over its range compared with swinging the first criterion over its range, as a percentage of the first criterion's 100 point swing weight. The process continues until all criteria have been ordered. The advantages to this method are similar to those for ordering preference, except that criteria ranking is adjusted to reflect the evaluators' judgments on relative criteria importance. A disadvantage is that the idea of relative importance of swinging criteria through their range is rather abstract and could be difficult for individuals to implement.

This method is implemented by adjusting the absolute weights to sum to one. This can be done manually or via supporting software. For large matrices it is suggested that, as with ordering preference, a software tool be used. Logical Decisions supports this process.

Weight Computation through Tradeoffs of Alternatives

In the weight computation through tradeoffs of alternatives method, two alternatives of equal preference are identified. This method is based upon the idea that equally preferred alternatives should have equal utilities. In this method, Team members identify pairs of equally preferred alternatives that differ on exactly two distinct criteria, C1 and C2. The tradeoff begins with each of the two alternatives receiving the best value for either C1 or C2, and the minimum for the other criterion. Alternative 1 receives the best value for C1 and the worst value for C2 and alternative 2 receives the best value for C2 and worst value for C1. (The alternatives have equal values for the remaining criteria.) In performing the tradeoff, team members start by identifying which of the two alternatives is most preferred. Is alternative 1, with the best value for C1/worst value for C2, preferred or alternative 2 with the best value for C2/worst value for C1? Assuming alternative 1 is preferred, the team members would identify the value change in C1 required to bring alternative 2 to an equally preferred value to alternative 1. The inputs are mathematically manipulated through the relationship Weight(C1) x Value change(C1) = Weight(C2) x Value change(C2) to establish relative weights for the criteria. The disadvantage to this method is that it requires a mathematical input for the value, and the change in value of an alternative against the two criteria. This information may be difficult to develop. Certain software tools, however, allow this to be performed graphically. Again, the software tool Logical Decisions supports this process.

Table 2.3.2 summarizes the various weighting methodologies described here, their limitations and strengths, and suggests potential applications appropriate for each.

Table 1. Criteria Weighting Methodologies Summary

Methodology	Limitations	Strengths	Recommended Uses
Direct Decision & Input	More prone to introduction of individuals' biases	Simple - No evaluation team effort required to select and weight criteria. Incorporates high level decisions not otherwise apparent to evaluators	When Decision Makers have expertise to determine relative importance of criteria
Weight Ratio – Simplified	Eliminates low importance criteria Consistency check of data is difficult, especially with large quantity of criteria Less conducive to hierarchy structure of criteria	Allows fast completion of criteria weighting in interactive session	When few criteria exist, criteria are independent of each other and criteria hierarchy structuring is not needed When least important criterion will not influence alternative selection
Weight Ratio – AHP	May need availability of software for efficiency of implementation in some applications Requires hardware and data inputting when results are required during interactive session	Accommodates numerous criteria, some of which are derived from others (Hierarchy Structure) Conducive to inputting some direct decision values and adjusting others accordingly	When sensitivity evaluations are desired When activity is complex When consequences of decision result in high risk to activity
Partial Weight Ratio	Can not perform check on consistency of individual's data See also Weight Ratio – AHP	Eliminates need for criteria comparisons that are difficult	When evaluators have difficulty with comparison of several criteria
Ordering Importance	Does not use relative values of criteria to determine weights Requires alternative with lowest score against all criteria	Direct comparison of criteria is not required Faster than AHP for interactive sessions	When a one-to-one comparison of criteria is not feasible
Swing Weights	Requires more time than Ordering Importance Abstract concept	Direct comparison of criteria is not required Conducive to expert/ decision maker inputs	When a one-to-one comparison of criteria is not feasible When more representative weighting is desired
Tradeoffs of Alternatives	Requires thorough knowledge of two available alternatives which are equally preferred Requires numerical alternative values	Compares criteria against an example	When alternatives are equally preferred but for different reasons When more representative weighting is desired

C.2.3.3 Alternative Selection

As with criteria weighting, selection of a preferred alternative can be done either through a manual or a software-assisted process. There are a number of recognized methods for selection of a preferred alternative. Six of these methods are described below.

Discussion of Pros and Cons

Almost invariably in an evaluation of multiple alternatives each alternative being considered has distinct advantages (pros) and disadvantages (cons) as compared to the other alternative(s). In this method these pros and cons become the criteria against which the alternatives are evaluated. For simple, minimal risk, non-complex, alternative evaluations in which the pros and cons are distinct among the alternatives, an acceptable method for selecting the preferred alternative is a general presentation and discussion of these pros and cons. Although weighting of these pros and cons is not required, the discussion should include a justification as to why the pros of the selected alternative are more important and the cons of less consequence than those of the other alternatives.

As an example, assume that the objective is to construct a new secondary road. Given alternatives of asphalt and concrete, the pros and cons listed are:

Table 2. Evaluation of Multiple Alternatives

	Pros	Cons
Asphalt	Lower capital cost Lower maintenance cost	Less durable
Concrete	More durable Higher capital cost	

In this case, since the lower maintenance cost of the asphalt would offset the durability of the concrete, an ensuing discussion would justify selecting asphalt based upon estimated usage and overall life cycle cost (capital plus maintenance costs).

Since this method presumes simplicity of the activity being studied, as well as the alternatives under consideration, the method is typically only used in informal alternative studies.

Nonweighted Criteria Method

This method for selection of a preferred alternative from among several choices involves the development and use of criteria. These criteria, however, are not weighted and is only slightly different from the pros and cons method described above.

In this method, a list of criteria is established, usually developed as a result of the evaluators' knowledge of the advantages and disadvantages of various alternatives. These criteria are then listed on one side (either the vertical or horizontal) of a matrix. Identified alternatives are listed on the other side. Each alternative is then evaluated against each criterion and assigned a comparative ranking. This ranking can be numerical or otherwise representative of the differences (e.g., +, -, 0). The alternative with the most positive score(s) becomes the preferred alternative.

As an example, consider again construction of a secondary road. If the previous alternative selection set of asphalt and concrete were expanded to include a dirt road, cobblestone, and brick, and criteria of "capital cost," "maintenance cost," "durability", "ride quality," and "aesthetics" were developed, a matrix could be generated as follows:

Table 3. Method for Selection of Preferred Alternative

	Asphalt	Concrete	Dirt	Cobblestone	Brick
Capital Cost	0	-	+	-	-
Maintenance Cost	+	-	0	0	0
Durability	0	+	-	0	0
Ride Quality	+	+	-	-	-
Aesthetics	0	0	0	+	+

From this matrix all alternatives except asphalt appear to average a neutral or lower score against the selected criteria. Asphalt averages a moderate + score. Thus, asphalt would be the preferred alternative.

An intuitively obvious disadvantage to this method is the lack of the relative importance of the criteria. Thus the usefulness of this method is greater when all criteria are relatively equally important or when the selection of an alternative is more a matter of simply making a choice and the resultant decision is essentially risk free.

Dominance Method

The dominance method compares all criteria of one alternative to another, as follows:

If the scores for all the criteria for one alternative are higher than these scores for another alternative, then the former alternative is said to dominate the latter. Because all criteria scores for one alternative are higher than those for the other alternative(s), this method does not require that the criteria be weighted. The alternative determined to be dominant becomes the preferred selection. This method is most useful when there are an exceptionally large number of alternatives and relatively few criteria, in that one alternative usually does not score higher than another alternative on all criteria, especially once the "less feasible" alternatives are eliminated. Although this method may be useful in reducing the number of alternatives, it usually will not yield a single preferred alternative.

Sequential Elimination Method

The sequential elimination method considers one criterion at a time to examine alternatives for elimination.

1. The alternative with the highest value for the most important criteria is chosen. If a number of alternatives perform equally well, they all remain viable.

2. The remaining alternatives are sequentially evaluated for each criterion, in order of descending importance of the criteria, until only one alternative remains. This alternative becomes the preferred selection.

Although this method is viable, its application is extremely limited in that it does not consider all criteria concurrently, and in fact, generally neglects those criteria with lower importance.

Minmax Method

The minimax method is initiated by having Team members identify, for each alternative, that alternative's lowest score against any of the criteria. The Team then determines which of the low scores is the highest. The alternative with the highest of the low scores becomes the preferred alternative.

As with other methods, this method may not definitively select an alternative. In addition, this method has the disadvantage of only considering each alternative's weakest criterion, independent of the relative importance of the criterion against the other criteria. Since, predominantly, the lowest criteria value for each alternative comes from different criteria, the comparisons are based on dissimilar standards.

Scoring Method

Use of a scoring method is the preferred technique for evaluating alternatives and selecting a preferred alternative. In the scoring method the merit of each alternative is determined by summing the contributions to that alternative from each identified criterion. In this method, weighted criteria must be used if the criteria have varying degrees of importance. In the scoring method of alternative selection, defined and weighted criteria are used to select the optimum from among a set of alternatives that meet the defined function. A simplified example of this process is provided in Attachment 9.

Aside from the simplified application provided in Attachment 9, two of the most common scoring methods for alternative selection are Multi Attribute Utility Theory (MAUT) and the Analytic Hierarchy Process (AHP). Either of these processes can be done manually, although the mathematical manipulation of data can become cumbersome. Generally both of these tools are applied with the assistance of software tools. The tool ECPro supports AHP, while the tool Logical Decisions supports both MAUT and AHP.

The foundation of the MAUT is the use of utility functions. These utility functions are intended to allow comparisons on a one-to-one, "apples to apples" basis for diverse decision criteria. Every decision criterion in the alternative study has a utility function created for it. The utility functions serve to transform the diverse criteria to one common, dimensionless scale or "utility." Once the utility functions are created, alternative raw scores can be converted to a utility score and then they may be compared with each other and an alternative score totaled for all the criteria.

The utility function converts an alternative's raw score against a given decision criterion to a normalized utility score which reflects the decision maker values. For example, assume that one of the decision criteria in an alternative study is to minimize cycle time and another is to minimize the amount of liquid waste generated. For this example alternative study, three alternatives have met all the requirements and are considered feasible. The following table shows the raw scores for the alternatives against the two decision criteria.

Table 4. Raw Scores for Alternatives by Decision Criteria

	Alternative A	Alternative B	Alternative C
Cycle Time (hours)	3	6.5	4
Liquid Waste (gallons)	22	5	15

Alternative Raw Scores

The figures below illustrate two possible utility functions for the two decision criteria. The range of utility values is typically from 0 to 1, but can be any range as long as it is consistent for each decision criterion. It can also be seen from the figures that the best raw score for each criterion is usually assigned the value of 1 and the worst raw score a value of 0. In this case, a 3-hour cycle time would receive a utility score of 1, and an alternative that generates 22 gallons of liquid waste would receive a score of 0.

The utility function for the cycle time is represented by a straight line indicating that the value system of the decision makers is directly correlated to the cycle time. That is to say, an increment of 1 hour is valued the same at the lower end of the cycle time range as it is at the higher end of the range (going from 4 to 3 hours cycle time has the same value in utility as going from 6.5 to 5.5 hours). The example utility function for the liquid waste criterion, on the other hand, represents a nonlinear relationship between "utility value" and gallons of waste produced.

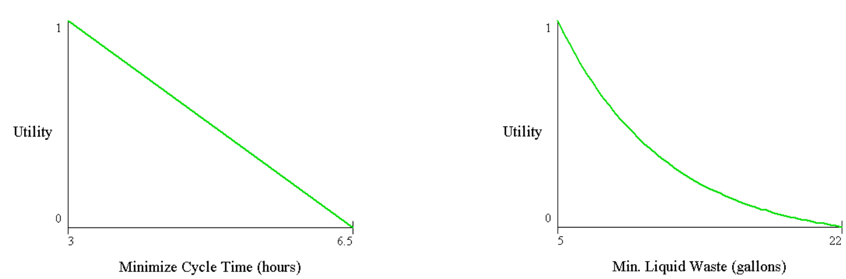


Figure C1. Utility Functions for 2 Decision Criteria

With this nonlinear utility function, an increment of one gallon of waste produced has a different utility at each end of the liquid waste produced range. This utility function indicates that moving from 5 to 6 gallons causes a significantly larger drop in utility score than moving from 21 to 22 gallons. This, in effect, says that the decision makers value an alternative that produces a small amount of waste much higher than one that produces waste at the larger end of the range.

Once the utility functions are generated and the raw scores are converted to utility scores for each of the alternatives, the utility scores can be converted to a weighted utility score (by multiplying the utility score by the weight of the decision criteria) and totaled for each alternative. See Attachment 10 for an example of alternative evaluation using the MAUT method.

The use of utility functions is typically employed when more information is known about the alternatives, resulting in firmer estimates of the alternative performance. However, the MAUT method can be employed when the alternative scoring is more subjective. When this is done the utility function is generated in the form of an analytic expression. This provision is especially helpful when detailed estimates of alternative performance are available for a portion of the criteria but several criteria remain more subjective. In this case, the alternative study should maximize the use of the well-developed information by utilizing the MAUT method with analytic expressions for some of the criteria.

Assume in the example given above that the cycle time criterion was less developed and actual estimates for the alternatives did not exist. In this example the higher level driver for the criterion was to minimize the total time it takes to completely stabilize a given type of material. Instead of knowledge about the cycle time for the process, assume that the decision makers had a more subjective feel for the time required to stabilize the material under each alternative (see table below).

Table 5. Alternative Scores

	Alternative A	Alternative B	Alternative C
Material Stabilized by	End of FY 2001	End of FY 2008	End of FY 2003
Liquid Waste (gallons)	22	5	15

Alternative Raw Scores (More Subjective)

An example utility function utilizing analytic expressions is provided in the table below for the minimize stabilization time criterion:

Table 6. More Subjective Alternative Scores

Utility Score	Expression for Alternative Performance
1	Material will be stabilized by the end of fiscal year 2001
0.5	Material will be stabilized by the end of fiscal year 2003
0	Material will be stabilized by the end of fiscal year 2008

Subjective Utility Function Example

With this utility function, Alternative A would receive a utility score of 1 and Alternatives B and C would receive utility scores of 0 and 0.5, respectively. It should be noted that, as in this example, when using this type of utility function a nonlinear value system may be applied. This function could have been created to represent a linear relationship between the utility score and time to complete stabilization.

When applying the MAUT method to the more subjective criteria, it is recommended that the descriptions of alternative performance be as detailed as possible and that a minimum of four or five utility scores be described. This will allow for a more consistent scoring to be applied to each of the alternatives. This is especially important when a large number of alternatives are being considered and when a large number of decision makers are evaluating the alternatives.

These examples presented a small number of possible utility functions. For more examples of utility functions see Attachment 11. As previously described for assigning weights to decision criteria, there are numerous methods for generating utility functions. Attachment 11 also provides a description of some of the methods for generating utility functions supported by the Logical Decisions software.

AHP uses "ratio values" rather than pure utility functions in selecting a preferred alternative. AHP does not require explicit levels for measures, although any of the measures can be defined based upon quantitative inputs. In this methodology, a preferred alternative is selected using pair-wise comparisons of the alternatives based on their relative performance against the lowest-level criteria in the hierarchy structure (see Attachment 6). The evaluation, or weighting of alternatives, is similar to the process defined for weighting criteria (see Attachment 8) - i.e., against criterion A, which alternative, 1 or 2, is better, and by how much – 1x, 2x, … 9x? This results in alternative preference weights for each of the lowest-level criteria. These alternative preference weights are then multiplied by their respective criteria weights and summed to produce overall alternative preference scores, with the highest score being the preferred alternative.

The major disadvantage of AHP, as perceived by some, is the fact that the process relies upon expert judgements of the decision-makers, both in prioritizing criteria and selecting a preferred alternative, using subjective pair-wise comparisons. Proponents of AHP, on the other hand, view this subjectivity aspect of the process as a definite positive in that it utilizes the knowledge base of the decision-maker.

Table 7 summarizes alternative selection methodologies, and their uses and limitations.

C.2.3.4 Sensitivity Analysis

In general, preference for one alternative is considered clear if the score for the preferred alternative exceeds the score for any other alternative by 10% or greater. In some instances this does not occur. In these cases a sensitivity analysis is recommended.

The purpose of a sensitivity analysis is to validate the alternative evaluation and ranking of alternatives that result from the decision process by demonstrating that small changes do not change the alternative ranking. These small changes could occur for the alternative scores against the decision criterion, decision criterion weights, or requirements.

The sensitivity analysis should evaluate the impacts of adjusting alternative scores up and down by approximately 10%. The Decision Team should insert raw score changes of ± 10% for each of the alternatives against the decision criteria. If these small changes don't change the overall results, then the analysis is insensitive to the alternative scores.

After verifying insensitivity to the alternative scores, the decision criteria weights should be checked for sensitivity. Once again, the Decision Team should make changes of ± 10% for each of the decision criteria weights while maintaining the 100% sum of the weight factors. If these changes don't result in a change in the alternative rankings, then the decision analysis is considered insensitive.

Making minor changes in the requirements is another possible check for sensitivities in the analysis. This could allow additional alternatives to qualify for the analysis by passing any go/no-go gates. This exercise is suggested when there are alternatives close to any requirement cutoffs.

Table 7. Alternative Selection Methodologies Summary

Methodology	Limitations	Strengths	Recommended Uses
Discussion of Pros and Cons	Relative importance of Pros and Cons not readily apparent. Limited to small number of criteria.	Simple to implement	Lesser risk applications, few alternatives, easily discernible pros/cons
Non-Weighted Criteria Method	Relative importance of criteria not readily apparent	Simple to implement. More conducive to higher number of alternatives and criteria than Pros and Cons method	Lesser risk applications
Dominance Method	Requires that one alternative be superior to another against all criteria. Does not typically result in a selected alternative	Quickly eliminates alternatives which could not be selected	To eliminate alternatives from a long list before performing a more formal alternative study.
Sequential Elimination Method	Ignores less important criteria. Does not consider alternative performance against all criteria.	Can be implemented quickly	When the highest one or two criteria dominate the decision as to which alternative will be selected
Minimax Method	Does not typically result is a selected alternative. All but one criterion are ignore: This criterion is different for each alternative	Can be implemented quickly	When all criteria are relatively equal in weight and alternatives are closely grouped in performance against the criteria.
Scoring Method – Simplified	Relative comparisons of alternatives against each criterion are fairly subjective. Limited to a small number of criteria.	Can be done in interactive session without computer hardware and software. Relative criteria value is considered	When the relative relationship among alternatives with respect to the criteria is clear and assigned values represent the differences
Scoring Method – MAUT	Requires development of and agreement with utility functions. Requires more well developed info on alternative performance.	Relative comparison of alternatives is the least subjective of any of the methods. Results in best understanding of decision maker values.	For complex, high risk decisions requiring easily interpreted and defensible results with well developed alternatives.
Scoring Method – AHP	Typically requires computer hardware and software for efficiency of effort. Relative comparison of alternatives will be a linear relationship	Does not require utility function. Relative criteria value is considered.	For complex, high risk decisions with less developed alternatives under consideration.

If any of these steps in the sensitivity analysis result in changes to the ranking, the Decision Team should reevaluate the criteria, alternative scores, or requirements that resulted in the sensitivity. This step is meant to ensure that the values and weights given to the element that caused the sensitivity are appropriate and that the team understands the impact that the element has on the decision. Following completion of the sensitivity analysis, confidence in the alternative rankings should be established.

It should be noted that the majority of the software available for decision making allows for sensitivity analyses to be performed very simply. Both the Logical Decisions® and ExpertChoice® software generate excellent graphs to analyze the decision sensitivity and both also allow for dynamic sensitivity analysis.

C.2.3.5 Special Case Criteria Development

Often the selection of an alternative is based upon criteria that are not straightforward or conclusive. In these cases, it may be required to evaluate the alternatives against these criteria using a "subordinate" supporting analysis or model. Some examples of this include:

1. Life-Cycle Cost Analysis

   Life-Cycle Cost analysis is used to evaluate the relative costs of the alternatives. Life-Cycle Cost analyses provide the following types of information:

   — Cost information for system effectiveness

   — Cost of development, manufacturing, test, operations, support, training, and disposal

   — Design-to-cost goals, any projected change in the estimate of these costs, and known uncertainties in these costs

   — Impacts on the life-cycle cost of proposed changes.

2. End-Product and Cost-Effectiveness Analysis

   End-product and cost-effectiveness analysis is conducted on system processes – generally life cycle processes – including such features as test, distribution, operations, support, training, and disposal. These analyses support:

   — Inclusion of life cycle quality factors into the end-product(s) designs

— The definition of functional and performance requirements for life-cycle processes.

3. Environmental Analysis

   Environmental analysis is used to identify and ensure compliance of the alternative(s) with all federal, state, municipal, and international statutes and hazardous materials lists that apply to the activity. These analyses include environmental impact studies to determine the impact of an alternative during the life cycle; on the infrastructure; on land and ocean, atmosphere, water sources, and human, plant, and animal life. Subcriteria in these analyses include such things as avoiding use of materials or the generation of by-products that present know hazards to the environment, and enabling integration and synchronization with activities that support NEPA documentation (e.g., Environmental Impact Statements and Environmental Assessments).

4. Risk Analysis

   Risk analysis is performed to identify the impact of undesirable consequences, based upon the probability of occurrence and consequences of an occurrence. The results of the risk analysis are prioritized and used as input to the alternative study.

5. Economic Analysis

   Economic analysis is conducted to eliminate as many cost biases as possible. An economic analysis involves evaluating all known costs of an alternative, from preconceptual activities through decommissioning.

6. Modeling and Optimization

   Modeling is used to facilitate an alternative study by describing a system via a simplified representation of the real world that abstracts the features of the situation relative to the problem being analyzed. There are four types of models in use: physical, analog, schematic, and mathematical.

C.2.4 Development of Results

Following selection of a preferred alternative, the Study Team develops details regarding the selected alternative to support the results. This supporting detail includes:

(1) Identification of the specific alternative or alternative features considered, inclusive of a thorough, but concise, description of these alternatives emphasizing those features that differ among them

(2) Advantages and disadvantages of the preferred alternative over the other alternatives

(3) A life-cycle cost comparison among the various viable alternatives, generally recommended as a relative life-cycle cost comparison in lieu of a complete life-cycle cost analysis.

Not all studies, nor all recommendations within a given study, require the same level of detail in developing the recommendations. The appropriate level of detail is that which is necessary and sufficient to justify the recommendations. Studies conducted at earlier stages of a project generally have less concrete quantitative data available than those conducted following conceptual or detailed design. Often costs are in "order of magnitude" terms and operations and maintenance costs are based on industry standard values for a given facility type or size. Studies conducted during construction and operation should contain a significant level of detail regarding cost differentials, including actual operations and maintenance cost comparisons, to justify changing an activity at that stage.

C.2.5 Presentation and Reporting of Results

With the exception of simple mental selection alternative studies, the results of all value engineering and alternative studies should be formally reported.

C2.5.1 Written Report of Study Results

Following completion of a value engineering or alternative study, the Study Team documents the results. For informal alternative studies this is often done as a part of another document. Formal alternative studies are typically documented in stand-alone reports. This documentation includes:

(1) Description of process/methods used

(2) Function analysis and/or functions against which alternatives were identified

(3) Identification of the various alternatives proposed, inclusive of a concise description or descriptive title of these alternatives

(4) Identification of the criteria and criteria weighting used to select the preferred alternative, including a description of the meaning of the criteria

(5) Identification of preferred alternative, including alternative evaluation against the criteria

(6) Development documentation of the preferred alternative (see section 2.4)

(7) Dates and time of the study

(8) Study participants and their past involvement with the activity.

A suggested report outline, intended to assure inclusion of this information, is provided in Attachment 12.

C.2.5.2 Oral Presentation of Study Results

Following completion of a value engineering or alternative study, one or more Team members may prepare a formal presentation for management/decision makers identifying the recommendations for changes to the activity under study. For value engineering studies, this presentation should clearly and concisely identify the "before" activity and the "after" or recommended activity, the advantages and disadvantages of implementing the proposed change, and a relative cost comparison between the proposed activity and the baseline activity. Alternative study presentations should clearly identify the various alternatives considered as well as the advantages and disadvantages of the alternative selected and, if available, a cost comparison among the alternatives evaluated. It is recommended that the Team member championing a given proposal present the proposal.

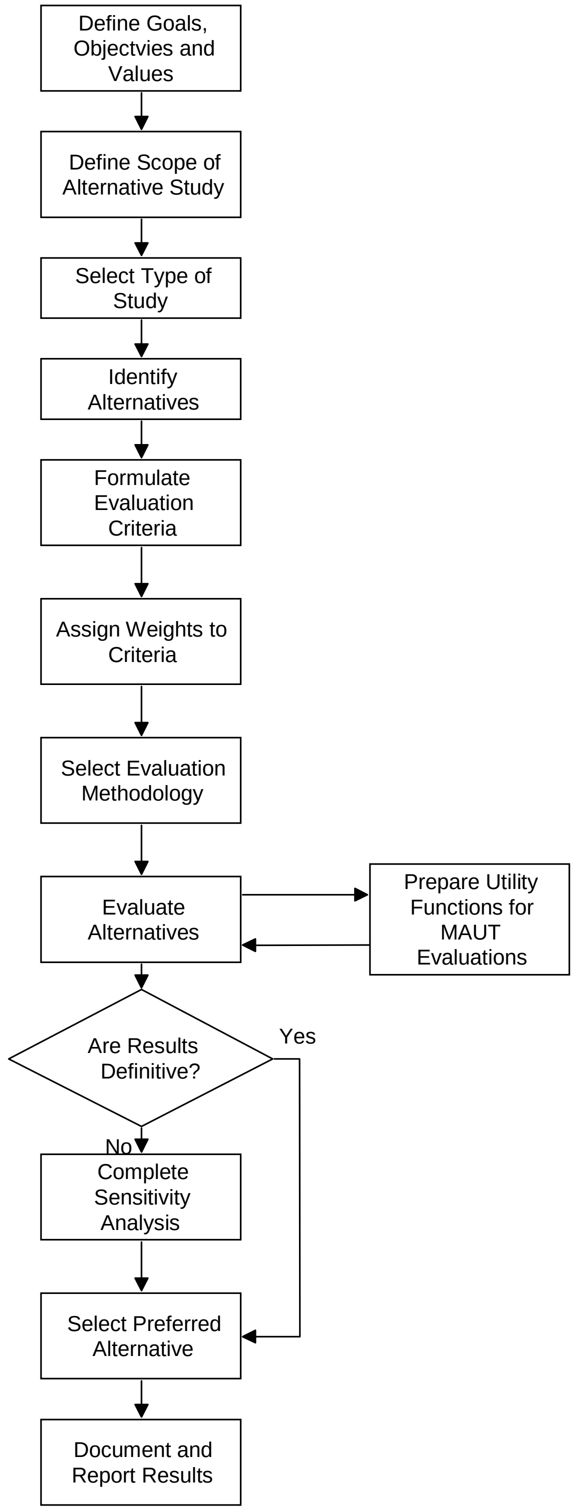
C.3.0 Study Closure

Closure of alternative studies and value engineering studies differ in a number of ways. Since participation by project personnel is expected in conducting alternative studies, an alternative study is considered complete when the study report is signed by a responsible manager within the area being studied (e.g., the Modification Manager or Project Manager for modifications/projects, the Facility Manager for activities affecting operations, etc.) or, in the case of alternative studies documented within another document, when the governing document is signed. Responsibility for implementation of any recommendations included in the study resides with this signature authority individual.

Because a value engineering study is conducted independently from the personnel responsible for the activity, these studies are not approved by cognizant activity personnel. Instead, these studies are only approved by the authoring personnel. In this instance, a formal transmittal letter is sent to the cognizant activity personnel requesting that they disposition the recommendations. Although a part of the value engineering report is documentation of potential cost savings, the cognizant activity personnel are expected to identify any actual cost, especially those which result in a budget change.

ATTACHMENT 1

ALTERNATIVE STUDY PROCESS FLOW CHART

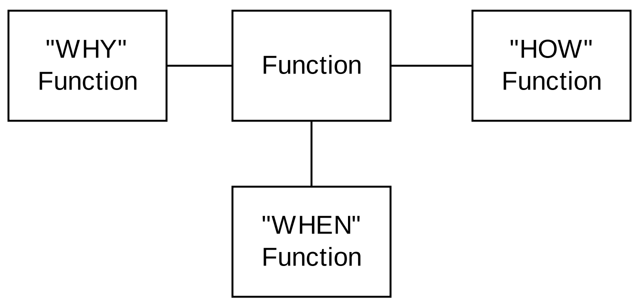


ATTACHMENT 2

FAST DIAGRAMMING

FAST diagramming is the creation of a logic structure of functions associated with a system, using a “HOW and WHY” relationship. A function immediately to the right of any other function on a logic path describes HOW the function is achieved. A function to the left of any other function on the path describes WHY the function is performed. A function directly below another function on the path identifies that the function on the path is accomplished WHEN the lower function is accomplished. The figure below illustrates this relationship.

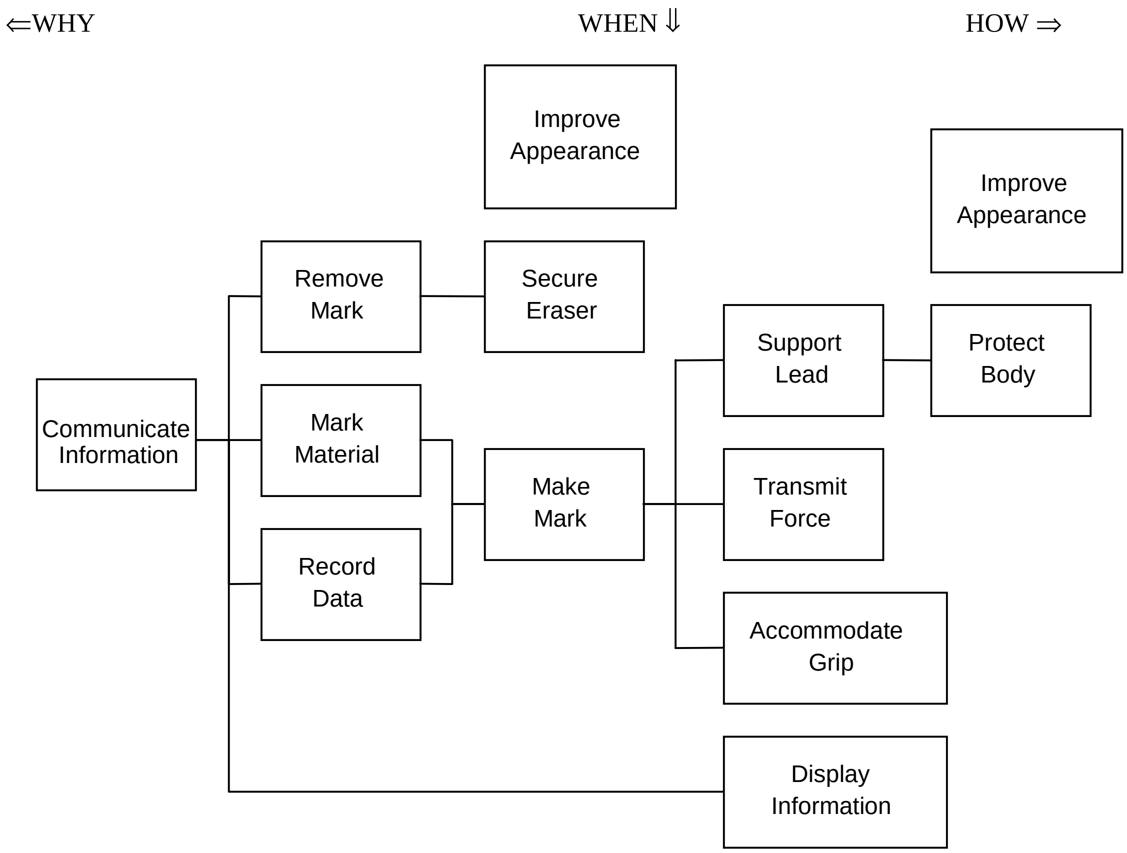
⇐WHY WHEN ⇓ HOW ⇒



A system can be complex or simple. Consider the following functions of the various components of a standard pencil.

COMPONENT	FUNCTION
Pencil (Assembly)	Communicate Information
	Mark Material
	Record Data
Body (Barrel)	Support Lead
	Transmit Force
	Accommodate Grip
	Display Information
Paint	Protect Body
	Improve Appearance
Lead (Graphite)	Make Mark
Eraser	Remove Mark
Band	Secure Eraser
	Improve Appearance

In tabular or list form these functions appear complete and are easily understood. Constructing a FAST diagram of these functions results in:



This diagram leads to questions that are not obvious from the list of functions, such as:

With the higher-order function of "Communicate Information," the [potentially] least costly way to meet the function may be verbal communication. If so, is the pencil needed at all? If the pencil is needed, is the higher-order function really "Communicate Information," or is it perhaps something like "Create Records?"

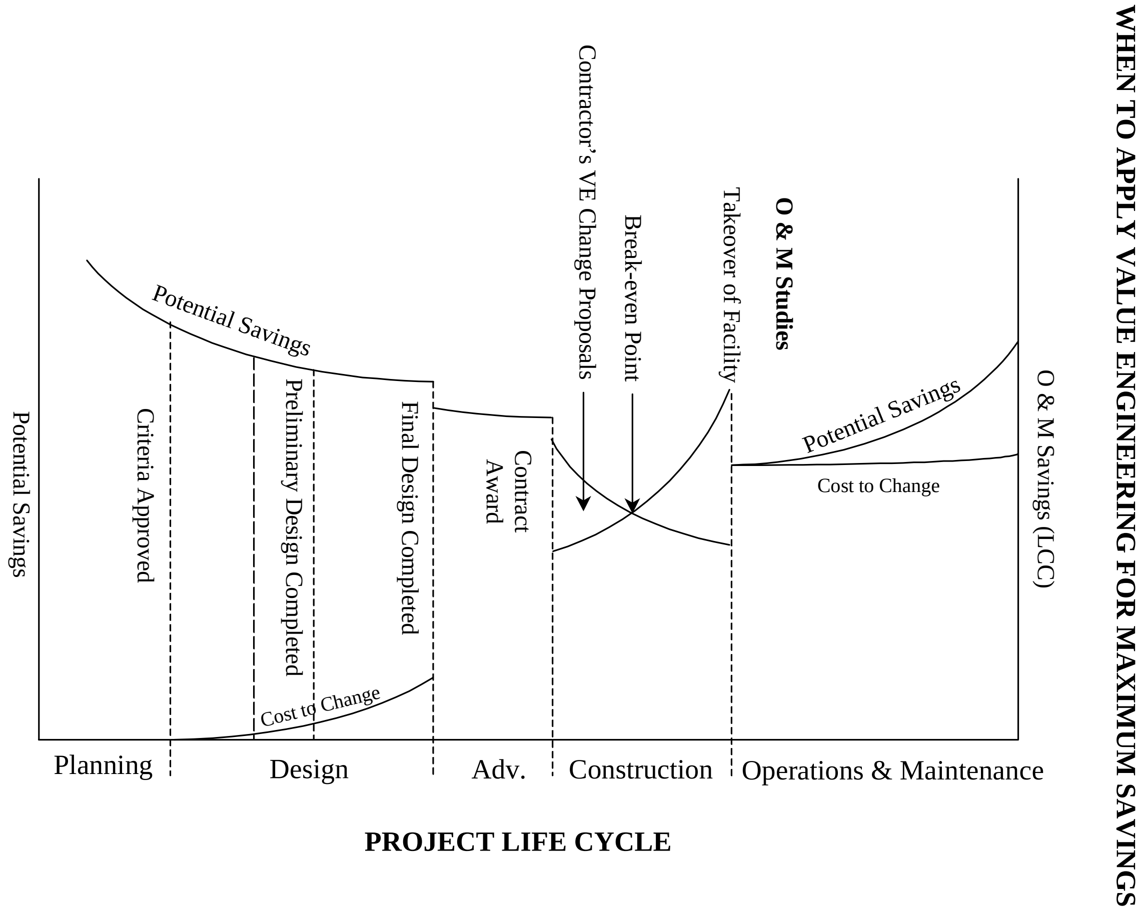
How does "Remove Mark" support the higher order function to "Communicate Information?" Is the component supporting this function (eraser) needed? Is there a function missing between them (e.g., "Obliterate Errors?").

Does "Improve Appearance" support the function of the pencil? Is this needed? Does it cost anything (or is it just a benefit of accomplishing another function)? Are we missing a customer-focused function that does require improvements in appearance?

Such questions, and the answers to them, are fundamental to value engineering in helping to evaluate if the design approach responds to the functional needs of the activity.

ATTACHMENT 3

POTENTIAL FOR SAVING FROM VALUE ENGINEERING STUDIES AT VARIOUS STAGES IN A PROJECT CYCLE



ATTACHMENT 4

HIERARCHICAL MODELING OF CRITERIA

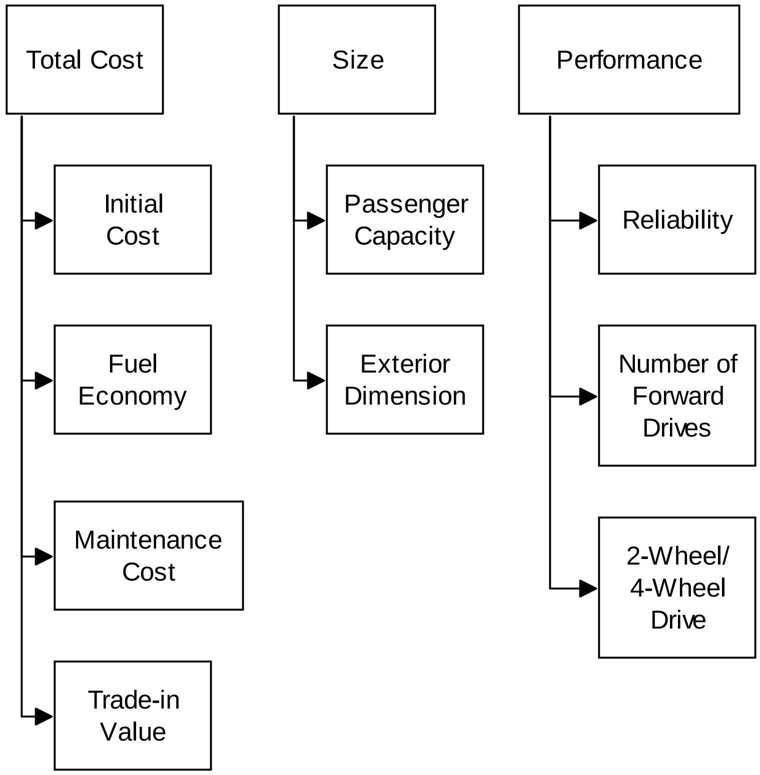
In many alternative studies there are a number of evaluation criteria identified that are not independent of each other or that are at such different levels of importance that direct comparison is difficult. In these cases it may be advantageous to group these dependent criteria into a structured hierarchical relationship. In a hierarchically structured criteria set, criteria are only evaluated against other criteria that are at the same level and under the same parent.

For example, suppose an objective is to buy new transportation. Without considering the specific alternatives, some criteria could be:

Total cost
Trade-in value
Maintenance cost
Performance
Fuel economy
Passenger capacity
Reliability
Exterior dimension
2-wheel/4-wheel drive
Number of forward drives/overdrive.

In comparing these criteria it would be very difficult to decide which is more important: total cost or maintenance cost, since maintenance cost is a part of total cost. It may be equally difficult to compare number of forward drives to total cost since they are such different levels that a direct comparison of which of these two is more important has little meaning.

If, however, this set of criteria is structured hierarchically, the “revised” criteria might appear as follows:



With the criteria in such a structure, only total cost, size, and performance are directly compared at the top level. At the next level, under the parent of total cost, initial cost, fuel economy, maintenance cost, and trade-in value would be compared relative to one another. By doing this, relative comparisons and relationships are easier to develop and understand.

ATTACHMENT 5

CRITERIA AND CRITERIA WEIGHTING

The table below illustrates a typical criteria weighting process. Each criteria is listed in both the row and column. Each set of criteria is then compared, once. The alpha in each block represents which of the two criteria being compared is the more important, while the number in each block represents by how much the dominant criterion is more important than the other. Once all comparisons are complete, the raw score for each criterion is determined by summing the numerical assigned to that alpha. These numbers are then either normalized to 10 (divide each score by the highest and multiply by 10) or converted to percents.

Criteria	A	B	C	D	E	
A. "Criterion A"		A1	A8	D2	A4	
B. "Criterion B"			B4	D3	B1	
C. "Criterion C"				D3	E2	
D. "Criterion D"					D1	
E. "Criterion E"						

Weighting Factors Legend:

No Difference								Very Important	
1	2	3	4	5	6	7	8	9	10

Scores:

Criteria	A	B	C	D	E
Raw Score	13	5	0	9	2
Normalized Score	10	4	0	7	2
Percentage Score	.45	.17	--	.31	.07

ATTACHMENT 6

CRITERIA WEIGHTING IN THE ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) uses matrix algebra and the eigenvector solution in an iterative process to determine criteria weights. An example of the process is as follows:[1]

1. Using pair-wise comparisons, an n^2 matrix is created where n is the number of criteria being compared. Values entered in the matrix are ratios of the importance, or priority, of one criterion over another. Values used in AHP generally range from 1 to 9, where 1 indicates equal importance and 9 represents almost an order of magnitude difference in importance.

   In the example shown below, criterion A is judged to be only half as important as criterion B (or $A_r/B_c = 1/2$), while criterion A is judged to be three times more important than criterion C (or $A_r/C_c = 3/1$). For the 3x3 matrix shown, the only remaining pair-wise comparison required is criterion B to criterion C, and in this example, criterion B is judged to be four times more important than criterion C (or $B_r/C_c = 4/1$). Since the diagonal of the matrix represents a comparison of each criterion against itself, each of these values, by definition, will be 1/1. The remaining matrix values (B_r/A_c, C_r/A_c, & C_r/B_c) are simply the reciprocals of the prior pair-wise comparisons.

	A_c	B_c	C_c
A_r	1/1	1/2	3/1
B_r	2/1	1/1	4/1
C_r	1/3	1/4	1/1

where: $_{r\ =\ row}$, and $_{c\ =\ column}$

2. The next step is to convert the fractional values to decimal equivalents of the desired precision,[2] and then compute the square of the matrix. For the example shown, $(A_r/A_c)^2 = (A_r/A_c \text{ x } A_r/A_c) + (A_r/B_c \text{ x } B_r/A_c) + (A_r/C_c \text{ x } C_r/A_c)$, or $(A_r/A_c)^2 = (1.0000 \text{ x } 1.0000) + (0.5000 \text{ x } 2.0000) + (3.0000 \text{ x } 0.3333) = 3.0000$. The remaining values of the squared matrix are calculated in a similar fashion.

	A_c	B_c	C_c				
A_r	1.0000	0.5000	3.0000		3.0000	1.7500	8.0000
B_r	2.0000	1.0000	4.0000	=	5.3332	3.0000	14.0000
C_r	0.3333	0.2500	1.0000		1.1666	0.6667	3.0000

[1] This example was extracted from the AHP Tutorial of the ECPro™ program CDROM available from Expert Choice, Inc., Pittsburgh, PA 15213.
[2] In this example, the desired level of precision is four decimal places.

3. Row sums are then calculated to produce the eigenvector solution and then normalized so that the sum is equal to 1. In the example below, criterion A has a value of 3.0000 + 1.7500 + 8.0000 = 12.7500, with a normalized value of 12.7500/39.9165 = 0.3194.

	A_c	B_c	C_c					
A_r	3.0000	1.7500	8.0000		12.7500		0.3194	
B_r	5.3332	3.0000	14.0000	=	22.3332	=	0.5595	(first iteration)
C_r	1.1666	0.6667	3.0000		4.8333		0.1211	
			Total	=	39.9165		1.0000	

4. The process is then repeated using the calculated values from the matrix of the previous iteration until the difference between two consecutive solutions is less than a prescribed, or desired, value.[3] Using values from the solution of the previous matrix and squaring this new matrix yields the following results.

	A_c	B_c	C_c				
A_r	3.0000	1.7500	8.0000		27.6653	15.8330	72.4984
B_r	5.3332	3.0000	14.0000	=	48.3311	27.6662	126.6642
C_r	1.1666	0.6667	3.0000		10.5547	6.0414	27.6653

5. Row sums are again calculated to produce the eigenvector solution, and that result is then normalized.

	A_c	B_c	C_c					
A_r	27.6653	15.8330	72.4984		115.9967		0.3196	
B_r	48.3311	27.6662	126.6642	=	202.6615	=	0.5584	(second iteration)
C_r	10.5547	6.0414	27.6653		44.2614		0.1220	
			Total	=	362.9196		1.0000	

6. The difference between the first two consecutive iterations is shown below. Since there is a difference to the fourth decimal place, an additional iteration is required.

	First iteration results		Second iteration results		Difference
A	0.3194	-	0.3196	=	-0.0002
B	0.5595	-	0.5584	=	+0.0011
C	0.1211	-	0.1220	=	-0.0009

[3] If the result of the iteration shows no change in the normalized value to the fourth decimal place, then another iteration is unnecessary.

7. Performing another iteration using the solution from the previous matrix and squaring this new matrix yields the following results.

	A_c	B_c	C_c				
A_r	27.6653	15.8330	72.4984		2295.7940	1314.0554	6016.8543
B_r	48.3311	27.6662	126.6642	=	4011.1349	2295.8740	10512.4476
C_r	10.5547	6.0414	27.6653		875.9853	501.3923	2295.7968

8. Row sums are again calculated to produce the eigenvector solution, and that result is then normalized.

	A_c	B_c	C_c					
A_r	2295.7940	1314.0554	6016.8543		9626.7037		0.3196	
B_r	4011.1349	2295.8740	10512.4476	=	16819.4565	=	0.5584	(third iteration)
C_r	875.9853	501.3923	2295.7968		3673.1744		0.1220	
			Total	=	30119.3346		1.0000	

9. The difference between the last two consecutive iterations is shown below.

	Second iteration results		Third iteration results		Difference
A	0.3196	-	0.3196	=	0.0000
B	0.5584	-	0.5584	=	0.0000
C	0.1220	-	0.1220	=	0.0000

10. Since there is no difference to the fourth decimal place, no additional iterations are required, and the criteria weights are defined by the values of the final iteration. For this example, the criteria weights are:

A = 0.3196

B = 0.5584

C = 0.1220

For a more rigorous treatment of the complete Analytic Hierarchy Process, readers are referred to *Multicriteria Decision Making: The Analytic Hierarchy Process*, Vol. 1, AHP Series, Thomas L. Saaty, RWS Publications, Pittsburgh, PA – 1990, extended edition.

ATTACHMENT 7

ALTERNATIVE SELECTION

The table below illustrates a typical alternative selection process. The top number in each alternative score block represents the alternative's relative score against the identified criterion. The lower number represents the alternative's weighted score (Relative Score x Criterion Weight). Note that from this table alone it is not evident why alternative 1 received a relative score of 4 and alternative 2 a relative score of 3, against criterion A, etc.

This example indicates that alternative 3 is the preferred alternative.

CRITERION -------->	A	B	C	D	E				TOTAL SCORE
CRITERION WEIGHT --->	10	5	0	7	2				---
ALTERNATIVE	ALTERNATIVE SCORE/WEIGHTED SCORE								
1. "Alternative 1"	4/ 40	2/ 10		4/ 28	2/ 4				82
2. "Alternative 2"	3/ 30	3/ 15		4/ 28	3/ 6				79
3. "Alternative 3"	4/ 40	4/ 20		4/ 28	5/ 10				98
Note that in this example Criterion D did not contribute to the differentiation among the alternatives and could be eliminated.									

Alternative Scoring Legend:

Worst Choice Best Choice

1 2 3 4 5

ATTACHMENT 8

EXAMPLE MAUT ALTERNATIVE EVALUATION

The following simple MAUT example is for a common decision that most people have made, the decision of which vehicle to purchase. In this case the vehicles under consideration are sport utility vehicles (SUVs). The alternatives have been narrowed to three: A, B, and C. There are five decision criteria defined and weighted as follows:

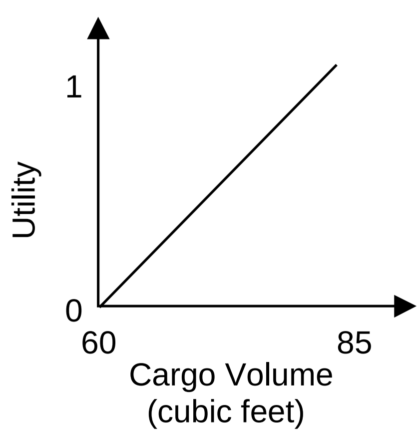
Weight	Decision Criteria
16%	maximize cargo volume
19%	maximize fuel mileage
24%	maximize horsepower
32%	minimize price
9%	maximize overall style and appearance.

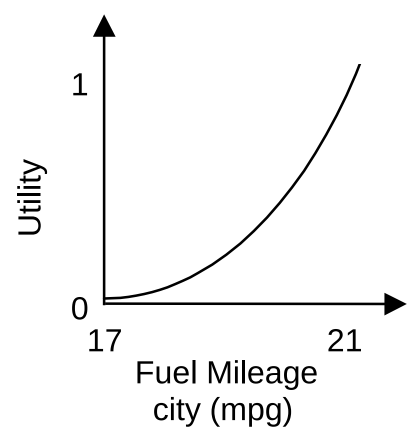
The alternative's performance against the decision criteria is given below in the Alternative Raw Values Table.

	Cargo Volume (cubic feet)	Fuel Mileage (mpg)	Horsepower	Price ($ x 1000)	Style/Appearance
Alternative A	85	17	210	32	Most Attractive
Alternative B	60	21	140	25	Least Attractive
Alternative C	78	18	173	28	Attractive

Alternative Raw Values

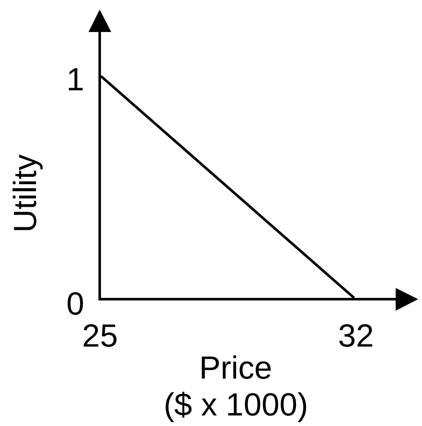
The decision maker generated the utility functions shown below for the decision criteria.

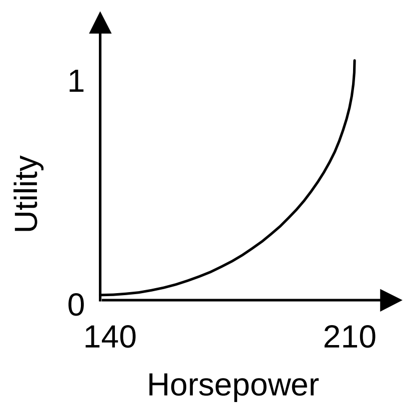




Style/Appearance	Utility

Most Attractive	1.0
Attractive	0.5
Least Attractive	0.0





Given the attribute performance as provided in the Alternative Raw Value Table and the utility functions pictured above, the alternative utility scores can be determined. The Alternative utility scores can be found in the Alternative Utility Scores Table.

	Cargo Volume (cubic feet)	Fuel Mileage (mpg)	Horsepower	Price ($ x 1000)	Style/Appearance
Alternative A	1.00	0.00	1.00	0.00	1.00
Alternative B	0.00	1.00	0.00	1.00	0.00
Alternative C	0.72	0.09	0.33	0.57	0.50

Alternative Utility Scores

Now that the alternative utility values have been generated, the alternative ranking can be calculated in the same general manner as the example in Attachment 9. The overall ranking of the alternatives is calculated in the Alternative Ranking Calculation Table below. The first and second columns of the table provide the decision criteria and the criteria weights, respectively. The alternatives are listed across the top of the table in the first row. The alternative utility scores are repeated in the upper left-hand corner of the separated entries in the table. The weighted alternative utility scores are found in the lower right-hand corner of the separated entries of the table. The weighted utility scores are calculated by multiplying the utility score by the decision criteria weight. The weighted utility scores are then totaled to calculate an alternatives overall score.

As seen in the Alternative Ranking Calculation Table, the alternatives overall rankings are as follows:

ALTERNATIVE	OVERALL RANKING
Alternative A	0.49
Alternative B	0.51
Alternative C	0.44

This example results in an overall ranking with the alternatives scoring too close to make a decision. This decision analysis should not be completed at this point. Rather, a sensitivity analysis should be performed and the decision criteria should be reviewed for additional criteria that may further distinguish between the alternatives.

	Relative Weight	Alternative A	Alternative B	Alternative C
Style/ Appearance	0.09	1.00 / 0.09	0.00 / 0.00	0.50 / 0.05
Cargo Volume	0.16	1.00 / 0.16	0.00 / 0.00	0.72 / 0.12
Horsepower	0.24	1.00 / 0.24	0.00 / 0.00	0.33 / 0.08
Fuel Mileage	0.19	0.00 / 0.00	1.00 / 0.19	0.09 / 0.02
Price	0.32	0.00 / 0.00	1.00 / 0.32	0.57 / 0.18
Total		0.49	0.51	0.44

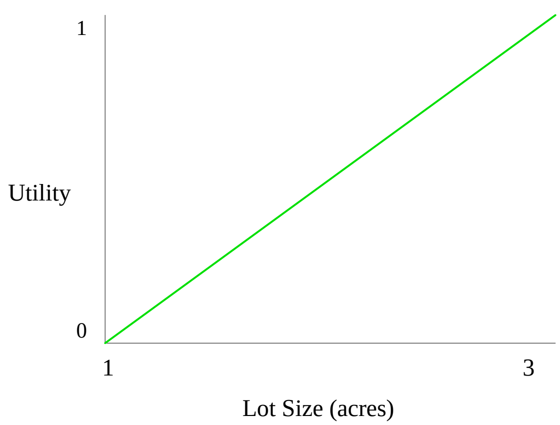
Alternative Ranking Calculation

ATTACHMENT 9

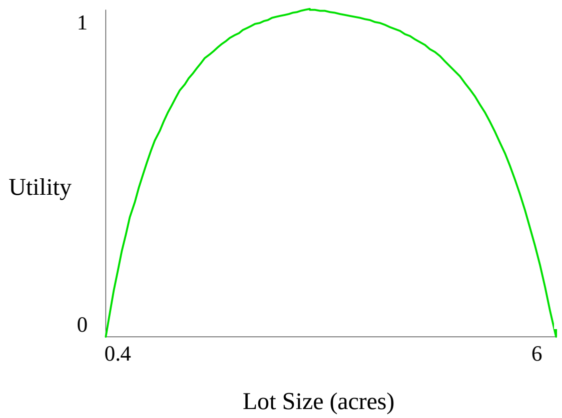
EXAMPLE UTILITY FUNCTIONS AND METHODS FOR GENERATING UTILITY FUNCTIONS

The following presents some of the possible utility functions that may be utilized to describe decision maker preferences. In these examples the decision criterion is related to the lot size and the decision being made is which home to purchase. There is a short discussion provided for each of the example utility functions in order to provide an idea of when the utility function may be applied.

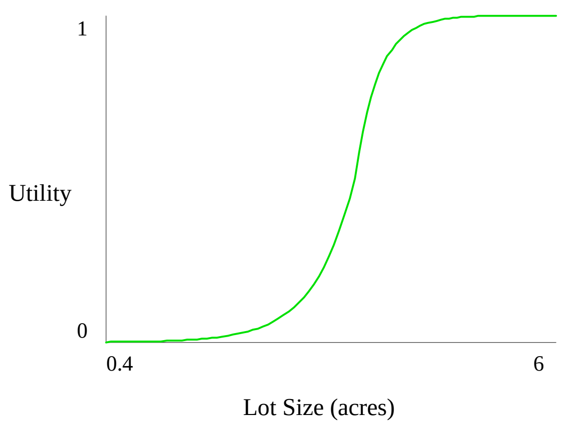
The straight-line utility function shown below is typically used when the range of performance for the feasible alternatives is reasonably close and there is no overwhelming preference for one end of the range over another. In this example, the prospective homeowner may have been interested in a home with a lot size of about 3 acres. The alternative homes had a relatively narrow lot size range of 1 to 3 acres and this resulted in a straight line utility function.



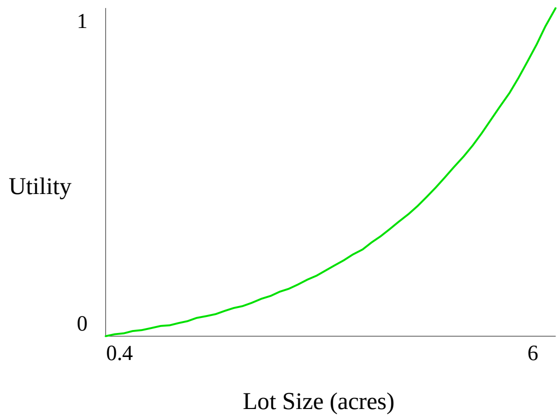
Like the example above, the prospective homeowner was interested in a home with a lot size of about 3 acres. In this case however, the alternative homes had lot sizes in a substantially larger the range from 0.4 to 6 acres. The decision maker may have felt that lots toward the smaller end of the range didn't offer adequate separation from the neighbors. Whereas the homes at the other end of the lot size range would involve too much yard work and therefore would be equally undesirable. With this utility function (shown below), homes with lots near the 3-acre point resulted in a higher utility score with respect to the lot size criterion.



This example utility function shown next again involves alternative homes with a lot size in the range from 0.4 to 6 acres. This utility function indicates that the decision maker values a home with a lot size in excess of 3 acres. Below 3 acres, the homes will receive a utility score close to 0. Above 3 acres, the homes will receive a utility score close to 1. Perhaps the decision maker in this case required a minimum of 3 acres to support animals and there was no aversion to a larger, 6-acre lot. This utility function closely resembles a go / no go requirement. In this example however, the homes with the lots less than 3 acres would have been eliminated had there been a requirement for lots with a minimum of 3 acres. Including a utility function similar to this in a decision analysis allows for the possibility of a home to be ranked high or the highest in the analysis because it performs very well with respect to other decision criteria rather than automatically be eliminated because of a requirement.



The shape of the next example utility function is the most common. In this example it is easily seen that the decision maker values the alternatives that have a larger lot size. The utility score remains relatively small until the lot sizes approach the larger end of the range when the utility scores increase rapidly.



The following describes some methods for generating utility functions that are supported by the Logical Decisions software. Details of the formulas and mathematical manipulations required to generate the utility functions are not provided, instead the choices and questions the decision maker must make are described. Additional information regarding the mathematics that the Logical Decisions® software employs to generate the utility functions can be found in the Logical Decisions for Windows™ decision Support Software User's Manual.

STRAIGHT LINE

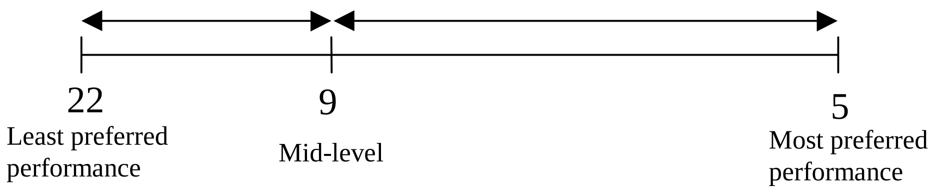
The most common type of utility function used is the straight-line utility function. To generate a linear utility function, typically the least preferred performance of the alternatives range of performance is assigned a utility of 0 and the most preferred level of performance is assigned a utility of 1. The utility function is then a straight line between the two points.

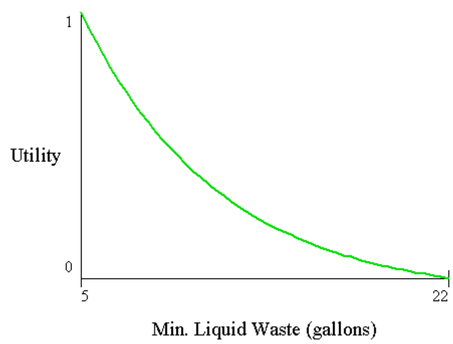
MID-LEVEL SPLITTING TECHNIQUE

This utility function generating technique seeks to establish the level of preference that is mid way between the least preferred and most preferred levels. The mid-preference level is identified by establishing two changes in the alternative performance level that have equal utility to the decision-maker. The figure below illustrates this. In this case, the decision-maker prefers the change from point A to point B in the same amount as the change from point B to point C. This technique assigns equal utility to changes 1 and 2 in order to generate the utility function.

Once the mid-level point is established, that point is assigned a value of 0.5 (for a utility scale of 0 to 1) and the utility function is drawn between the mid-level point and the least and most preferred levels. The example used in Section A.2.3.3 for the minimize liquid waste criteria is summarized below. The alternative performance, the mid-level, and the corresponding utility function are each shown.

	Alternative A	Alternative B	Alternative C
Liquid Waste (gallons)	22	5	15





When using this technique to generate the utility function, the decision-maker must answer a series of questions about changes in performance until the mid-level can be established. For the minimize liquid waste criteria example, these questions could have started with: "Is the change from 22 to 13.5 (13.5 is the mid-point between 22 and 5) gallons more important or the change from 13.5 to 5 gallons?" The decision-maker would have answered with "13.5 to 5 gallons." Then the range would have been narrowed and another question asked: "Is the change from 22 to 9 gallons more important or the change from 9 to 5 gallons"? In this example the decision-maker then would answer that the change from 22 to 9 and the change from 9 to 5 gallons are equally important. Therefore 9 is the mid-level preference. This is a very simplified example, and in practice this method will take more probing to arrive at the mid-level.

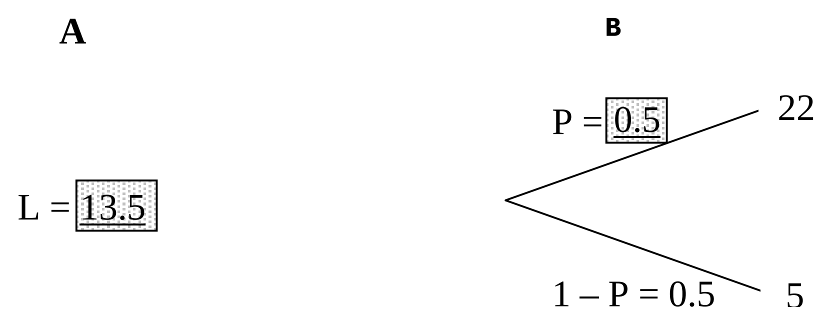
PROBABILITY TECHNIQUE

The probability technique allows the decision-maker to generate the utility function by answering a probability question. When this technique is employed, the decision-maker is asked to compare an alternative (A) that has a definite value for the decision criterion with another alternative (B) that has a lottery, or uncertain value, for the same decision criterion. Alternatives A and B differ only on the single decision criterion that the utility function is being generated for, they are equal with respect to the other criteria.

Consider the minimize liquid waste example above and the three alternatives A, B, and C. The alternative performance against the criteria is repeated below:

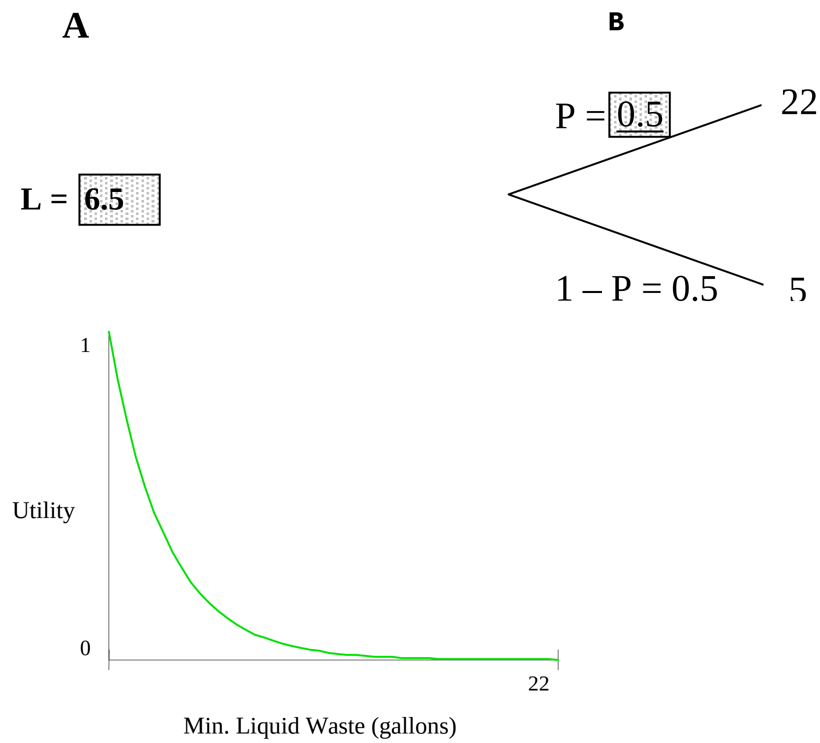
	Alternative A	Alternative B	Alternative C
Liquid Waste (gallons)	22	5	15

In this example the range of performance is between 5 gallons and 22 gallons and the mid-point is 13.5. The comparison in the Logical Decision software would start as:



This default is asking the decision maker if a certain value of 13.5 gallons of waste produced is equal to a lottery with equal chance (P=0.5 and 1-P=0.5 or 50% probability) of ending up with 22 gallons or 5 gallons. If these two alternatives are equally preferable, the decision maker would indicate that and the utility function would be a straight line. More than likely, the default will not be equally preferable and the decision maker will be asked to adjust the certain outcome "L" and the probability "P" such that alternatives A and B are equally preferable.

Assuming that the decision maker adjusts "L" to 6.5 and indicates that alternatives A and B are equally preferable, the utility function shown after the equal alternatives A and B would be generated.


A
B
P = 0.5
22
L = 6.5
1 – P = 0.5
5
1
Utility
0
22
Min. Liquid Waste (gallons)

ATTACHMENT 10

TYPICAL ALTERNATIVE STUDY REPORT CONTENTS

Abstract or Forward

Introduction

Provide a general description of the scope, purpose, and timing of the study.

Background

Provide a brief description of the activity being studied.

List of Participants

Identify the study participants.

Study Limitations and Assumptions

Identify any limitations imposed on the study and any key assumptions.

Methodology

Describe the methodology used in the conduct of the study.

Discussion of Results

Provide a detailed discussion of the evaluation(s) conducted and the results of the evaluation(s).

Summary/Conclusions

Provide a summary of the results of the study.

Recommendations

Identify recommendations resulting from the study.

Attachments

For value engineering studies, the FAST diagram is included, either in the methodology, results, or attachments.

Practice 7

7

Baseline Development and Validation

7 BASELINE DEVELOPMENT AND VALIDATION

7.1 OVERVIEW

Each project shall have a formally approved and communicated baseline that describes the integration of the technical objectives and requirements with the schedule and cost objectives. The baseline is included in the Project Execution Plan. At Critical Decision CD-1, Approve Preliminary Baseline, a preliminary baseline range will be adopted by the project until it is replaced by the performance baselines at CD-2, Approve Performance Baseline. The scope (technical), schedule, and cost processes are the three key elements used to establish an integrated approach to project baselines.

The five principle reasons to establish baselines documents are to

- ensure attainment of project objectives.
- manage and monitor progress during project execution.
- define the project for approval and authorization by the DOE, by the Office of Management and Budget (OMB), and by Congress.
- ensure accurate information on the final configuration (as-built drawings, specifications, expenditures, etc.).
- establish performance measurement criteria for projects.

Development of the baselines begins with the planning cost, schedule estimates, and the preliminary scope included in the Justification of Mission Need and is further defined in conceptual design documents. All capital asset projects will be required to have their baselines independently certified through an independent cost estimate (ICE) review which addresses the technical, schedule, and cost baselines.

All DOE capital-asset projects, irrespective of funding type, will be reviewed as part of the annual budget validation process. A tailored approach will be used to assess readiness to proceed and the ability to use planned funding. General plant projects, capital equipment projects, and operating expense-funded projects that are $5M or less are the validation responsibility of the operations or field office managers. The DOE Controller (CFO) will issue DOE project validation guidance annually through the Budget Call for the coming year.

Program Secretarial Offices (PSOs) are responsible for conducting all project ICE baseline verifications/validation reviews including Major Systems. The PSOs may delegate project validation responsibility to operations or other field offices.

Where delegated, field offices will supply the appropriate Headquarters program validation coordinator with a list of all projects proposed for annual budget validation, a formal report in the format specified in the annual Budget Call and signed by the validator should be submitted to the Headquarters program office for formal concurrence and submittal to the CFO.

7.2 PURPOSE

A project baseline describes a desired end product and associated schedules and costs.

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

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

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

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

Once a site develops, its project integrated baseline, the OECM, working with the site, is responsible for ensuring that the life cycle site baseline is independently reviewed and validated to prove that it is defensible relative to scope, schedule, and cost. A credible and independent review of each site's baseline is an expectation of Congress, OMB, local stakeholders, Tribal Nations, and the DOE. Baseline verification (validation) is a one-time event. Once a baseline is verified (validated), it should not generally require revalidation if changes are managed through a rigorous change control process. Completion of a rigorous independent verification review should reduce the need to subject the site to additional resource-consuming audits, and reviews by other organizations. This independent life cycle baseline verification review is not to be confused with the budget validation that is conducted by the field organization during the annual budget formulation process.

7.3 Application

7.3.1 Baseline Development

A project baseline contains three elements:

- the scope (technical) baseline
- the schedule baseline
- the cost baseline.

The scope (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). The scope is the basis for the schedule and cost baselines. These three baselines are tightly coupled, and a change in one baseline generally affects 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.

The technical baseline is the reference set of high-level technical documents that contain the technical requirements necessary to satisfy mission needs. The schedule baseline is the set of approved milestones derived from, and consistent with, the technical logic. The schedule milestones are traceable to elements within the WBS. The cost baseline is developed by allocating resources and estimated costs against the scheduled activities for the total scope of work. The cost baseline supports the technical work scope, is traceable to the WBS, and is time-phased and aligned to the schedule baseline and mission elements.

Baselines are controlled through the application of the configuration management and baseline change control processes, and will evolve as the project matures.

Baseline details and precision increase as a project progresses. For a conventional construction project, phases may include concept development, preliminary design, detailed design, and construction. Project engineering and design (PED) funds become available for the preliminary and final design and baseline development. Projects with a Total Project Cost (TPC) of $5M or more, require an external independent review (EIR) verification of mission need and baseline. For environmental restoration, this is usually assessment and design. During early project phases, baseline development may, if schedules or costs do not meet expectations, 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.

7.3.1.1 Scope (Technical) Baseline Development Process

The scope (technical) baseline development process requires management actions necessary to formally establish the project mission, functional objectives, design or characterization requirements, and specifications in order to define, execute, and control the project scope of work (Figure 7-1). The technical requirements are the basis for development of the project's WBS, cost estimate, schedule, and performance reports.

The contractor must establish a scope baseline from which work can be accomplished and performance measured. The contractor scope baseline is developed after the project's mission, technical objectives, and functional requirements (or equivalent objectives such as environmental assessment requirements) are established by the project manager and included in the project documentation, e.g., PMP. The formally approved technical objectives and requirements are baselined at Critical Decision 1 (DOE approval of conceptual design or equivalent report such as an assessment work plan for environmental subprojects). The scope

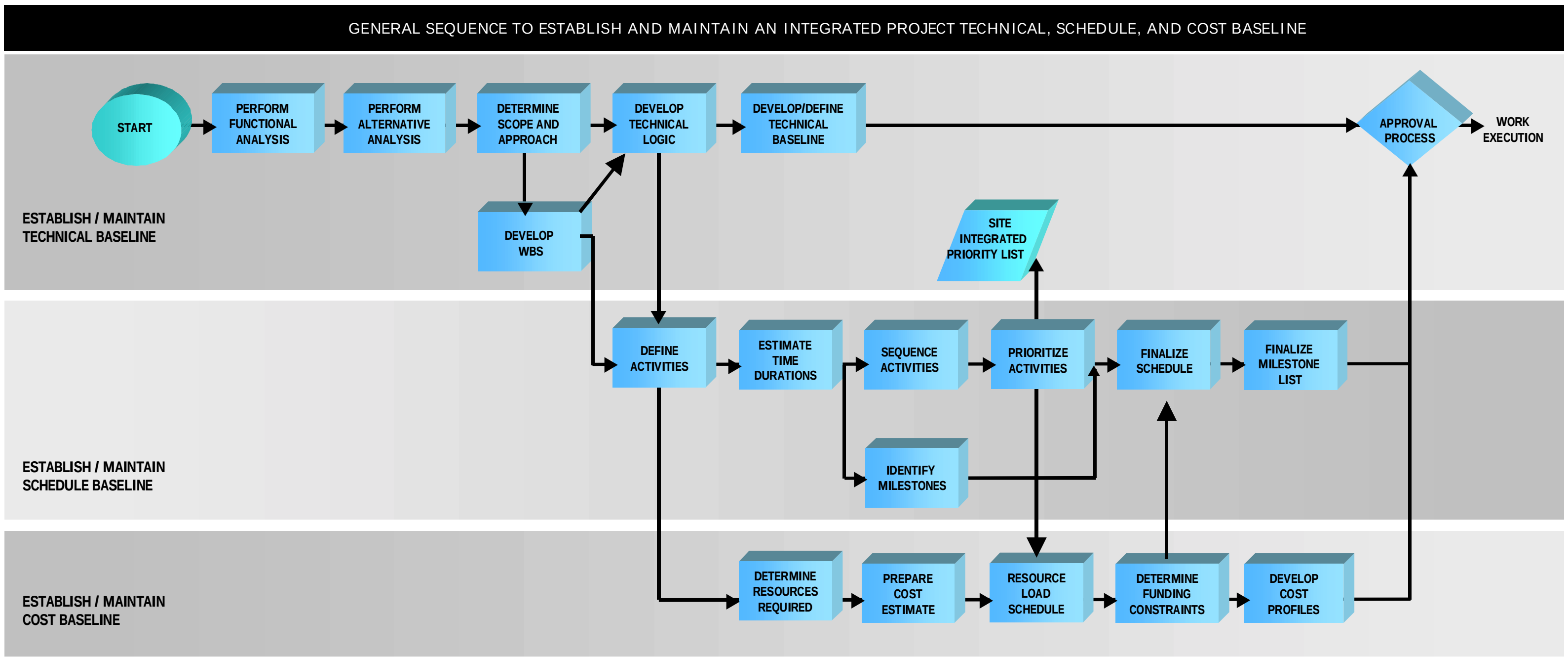


Figure 7-1. Scope (Technical) Baseline Development Flowchart

(technical) baseline and work scope definition guideline requires that the contractor scope baseline be contained in formal documentation, such as a conceptual design report or an environmental cleanup work plan, and be approved by the DOE. This is the point from which technical aspects of the contract work will be subject to formal change control.

All authorized project work shall be defined in a Work Breakdown Structure (WBS) that represents the way the work will be estimated, scheduled, budgeted, performed, and managed. The WBS shall be maintained consistent with project needs throughout the life of the project, ensuring changes to the WBS are made within a formal change control process.

All projects should have a clearly defined work scope to accomplish the DOE prescribed scope baseline. The work scope must be described in sufficient detail to ensure that functional design requirements, major physical attributes, and performance characteristics are clearly accomplished.

Project risk factors must be considered when developing the WBS. The primary purpose of the WBS is to divide and organize work into manageable sized units. Requiring added levels of the WBS will in turn require a further division of the work into progressively smaller units, which may be required on more complex projects of higher risk.

The scope baseline must be established such that scope performance can be measured and controlled throughout the life of the project. Monitoring and controlling scope performance involves tracking the achievement of the scope baseline at the contractor level. The scope baseline must be hierarchically related such that monitoring scope performance at the contractor level is related to the accomplishment of higher level (DOE-controlled) baselines pertaining to the objectives and mission of the project. The scope baseline must also relate to the schedule and cost baselines to allow scope performance monitoring to correlate with cost and schedule monitoring.

Changes to the WBS should not be made once work has started, although sometimes changes are necessary to make corrections. Some WBS changes, such as splitting work scope into multiple WBS elements, may cause a significant disruption to the project control system if some of the work has already been performed and actual costs incurred. Changes to the WBS normally result as a project progresses through its phases such as design, procurement, construction, test, operation, etc.; and when project re-scoping occurs. An example of expected changes to the WBS would be the expansion of WBS elements as future work becomes more definite “or” the aggregation of the WBS elements in the same leg of the structure if less detail is required to effectively manage the work.

The work defined in the contract scope of work and subsequently organized in the WBS should be assigned to the specific cost account managers in the organizational elements that are responsible for managing and performing the work.

The cost account manager(s) should be identified as early as possible to permit participation in the planning and scheduling process. The schedule that is developed for performing the work should have the involvement of the responsible cost account manager. The schedule developed by the cost account manager will define the work approach and sequencing with activity logic, and identify the resources estimated to complete the work within the activity durations assigned. The project must have the cost account manager assigned before the work starts.

7.3.1.2 Schedule Baseline Development Process

When establishing the schedule baseline all known requirements affecting a project must be identified and considered in the development of project baselines, and all project work is scheduled using a disciplined, integrated approach.

Schedules shall be developed that are consistent with the WBS and integrated with the cost estimate, and shall represent all project work scope regardless of funding source. Activity logic will be developed to depict all work scope, constraints, and decision points. Time durations will be estimated and assigned to activities representing work accomplishment. Development of schedules must be in concert with the WBS such that all work is represented in the schedule, and accurate durations are established.

Schedule activities should be traceable to the cost estimate and the WBS. Schedule activities, durations, and sequencing relationships are conceptually developed in conjunction with the development of the project cost estimate. The cost estimate is generally calculated below the lowest level of the WBS and provides one means for estimating activity durations.

Activities and logic should be planned by WBS element first, to permit the checking of activities and logic with the WBS element scope of work and technical requirements. After determining that adequate activity planning against the WBS element has been accomplished, the integration of activity logic between WBS elements is performed. Logic links must be developed thoroughly enough to allow an accurate critical path to be calculated in order to serve as the basis for forecasting and decision-making throughout the life of the project.

A tailored approach should be used when determining how much detail will be included in the schedule. Basic guidance for determining the extent of activity detail is that the number of activities should not be so few as to prevent suitable progress tracking, and not so numerous that the number of activities overwhelms the system and its users, rendering the schedule logic incomprehensible and too burdensome to status.

An approved schedule baseline must be established that clearly depicts critical path activities and milestones from which actual performance for all activities and milestones can be compared, and from which forecast data can be generated. Resource-loaded activities, as required and at the appropriate level, will be used to develop time-phased budgets that are integrated with the schedule. Only approved changes to the schedule baseline will be permitted.

Project schedule activities (not milestones) should be resource-loaded to facilitate analyses of "what if" funding scenarios. Resource-loaded schedules assist the Project Manager and the contractor in developing time-phased budgets and spending profiles. On projects using critical-path method schedule networks, schedules should be resource-loaded at a summary level; resource-loading within the same scheduling database is desired but not required.

Where logic relationships are established, the detailed level of the schedule, is the focal point of a project's scheduling system from which all scheduling reports are generated. The detailed critical path schedule is normally 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.

Technically significant events, such as design review completions, delivery of major equipment, regulatory or interagency commitments, etc., should be considered in developing milestones. Milestones should be selected with consideration given to the critical path.

Milestones are much like schedule activities in that too many may become unmanageable, and too few may not provide the required visibility. Milestones should be meaningful and should be selected at time intervals that will allow a consistent and thorough depiction of project progress. Milestones are an integral part of the project schedule database and are reportable to varying accountability levels. To allow traceability through the WBS from higher levels to lower levels, milestones that are contained in the schedule database should also have logic links to activities as appropriate, and should be coded to roll up to selected WBS levels.

All known project and contract requirements, major procurements, milestones, and constraints must be identified for the planning and scheduling process. Activities external to the project that could reasonably be expected to impact the project must also be considered. All project work must be scheduled using a formal, documented, consistent approach. The schedules should reflect planning by the appropriate technical expertise as to how the activities will be accomplished. The initial schedule from which performance will be measured, developed at CD-1 (or an environmental clean up work plan), establishes the project schedule baseline which includes project milestones. Modifications to the schedule baseline are subject to formal change control.

Establishing milestones at the different levels of management control creates an integrated milestone hierarchy. That is, the lower-level milestones should be established to help measure schedule performance and to support upper-level milestones. The measurement of progress toward completing a high-level milestone is important and can be done with reasonably spaced lower-level milestones that depict interim schedule assessments. The range (or roll-up) are low-level schedule and milestone tasks that support master schedule and milestone lists.

7.3.1.3 Cost Baseline Development

Cost baselines are developed to ensure that budgets for labor, services, subcontracts, and materials are established at the proper levels and are "time-phased" in accordance with the project schedule. This ensures that the Total Project Cost (TPC) is noted within the system and that the project direct costs and indirect costs are identified and managed.

Developing a cost account structure that integrates with the WBS and facilitates the collection of expense and capital costs by organization and cost element, as appropriate, establishes a process for controlling the opening and closing of cost accounts for the life of the project.

Each cost account must have scope, schedule, and budget. That is, budget must be estimated for the scope of work contained in the account, and must be time-phased in accordance with the project schedule. Time-phasing of the budget in accordance with the schedule may be accomplished manually by the cost account manager, or with a resource-loaded schedule network for complex projects. Time-phasing of the resource requirements must be performed in a way that represents the way the resources will be accounted for when costs are incurred. The basis for the budget that is time-phased in the control account must be supported by, and reconcilable to, the cost estimate and schedule.

All work must be represented in cost accounts, and the sum of all cost account budgets, contingency, reserves, and fee, equals the TPC or contract value, as appropriate.

A project's cost baseline is a budget that has been developed from the cost estimate and has been timed-phased in accordance with the project schedule. The cost baseline is referred to as a baseline since it is subject to formal monitoring and controls, and is integrated with the technical and schedule baselines.

When combined with other cost baseline components, form budgets with unique purposes as listed below:

1. When added together, the sum of all cost baseline components for all contracts equals the TPC.
2. The sum of the direct, indirect, contingency and management reserve, and undistributed budget equal the total dollar amount allocated for the project/ contract scope of work.

Project cost and schedule baselines shall provide the basis for multi-year work planning. These baselines will also be used to generate annual budget cycle products including Project Baseline Summaries (PBSs), project data sheets, funding requests, Paths to Closure data, IPABS-IS data sheets, and so forth.

7.3.1.4 Baseline Change Control

Once the technical, schedule, and cost baselines are clearly defined, documented, and approved (CD-1 Preliminary Range and CD-2 Performance Baseline), they must be controlled by a formal and documented control management process. Project baseline changes will experience the need to have various levels of approval authority. Contractor-level baseline changes may be made by the contractor without DOE approval, but the changes will be documented and provided to DOE for information on a regular periodic basis as defined in procedures and stated in the Project Execution Plan (PEP).

Contractors and DOE should process and implement change requests in a timely manner. Contractors should not allow changes to performance data (cost plan, earned value, costs, or schedule) that have not been recorded and reported for completed work. The only exceptions are to correct errors and to make accounting adjustments. Contractors may internally re-plan future work when the re-plan will result in more efficient or effective ways to perform the work as long as no DOE milestones are unfavorably impacted or additional budget is required.

Internal replanning must be coordinated with and approved by the project manager. Such re-planning is included in the next regularly scheduled project report.

7.3.2 Project Baseline Verification (Validation)

Baseline external independent reviews are to be conducted by personnel that are recognized as qualified in their respective fields of expertise and are outside the project organization. These reviews assess the reasonableness of the technical approach and project scope, schedule and cost baselines, and also assess the potential for schedule and/or cost improvement. The timing and scope of independent baseline reviews will depend on the type of project and the baseline element (technical, schedule, cost) being considered. An independent review of technical requirements, technical approach, and scope of a new project should be conducted before the baseline schedule and cost estimate are developed, while technical, scope, schedule and cost will all be reviewed at the same time for subsequent reviews or for a baseline change package. The need, frequency, and depth of each review will be established by considering minimum requirements for conducting specific reviews or by using a tailored approach to consider the maturity of scope definition, the nature of the activities being reviewed, and the risks associated with the baselines. All projects having a TPC greater than $5M must have an independent baseline review prior to receiving CD-2.

The OECM will select the validation organizational team. A team or organization that is clearly independent of the business implications of the validation results will conduct the independent baseline validation. For example, Headquarters Site Team members or Operations Office staff should not participate in the independent validation for their assigned sites, although they may participate as observers. The verification/validation team or organization should not have contributed to the development of the baseline or project planning documents, nor should it experience any positive or negative effects from the validation finding. Independent baseline reviews will focus (1) on satisfying technical mission requirements and (2) the reasonableness and validity of the baseline cost and schedule; by using appropriate estimating techniques and comparisons to benchmark costs where applicable. The outcomes of the review must be discussed, negotiated, and then incorporated into the project baseline through the change control process.

Independent baseline reviews are those used to verify the completeness and reasonableness of cost and schedule baselines and any other estimates or schedules used to analyze project alternatives or support management decisions. These reviews (1) are typically performed before approving the cost and schedule information for use to support budgetary document or management decisions and (2) should be thoroughly documented for future reference.

Annual project budget validation usually applies to all line-item construction or capital asset projects. It is the formal process of evaluating project planning, development, baselines, and proposed funding before including projects or system acquisitions in the DOE budget. Validation requires a review of project planning and conceptual development documentation; as well as discussion with the program or field element and principal contributing contractors, to determine the source basis, procedures, and validity of proposed requirements, scope, schedule, cost, and funding. Findings and recommendations resulting from the budget validation process will be provided for use in formulating the annual budget. Specific guidance for conducting budget validations is provided annually by DOE-HQ.

The independent baseline review and validation processes are not intended to replace or duplicate the peer review processes and procedures of each contractor. Thorough and effective peer review, using personnel either internal or external to the contractor organization, is essential to ensuring that all project baselines and baseline change requests submitted to DOE are reasonable, complete and accurate, and can withstand an independent review.

Practice 8

8

Risk Management

8 RISK MANAGEMENT

8.1 INTRODUCTION

8.1.1 Purpose

Risk is the degree of exposure to an event that might happen to the detriment or benefit of a program, project, or activity. It is described by a combination of the probability that the risk event will occur and the consequence of the extent of loss or gain from the occurrence.

Risk management is a structured, formal, and disciplined approach, focused on the necessary steps and planning actions to determine and control risks to an acceptable level.

Project risk management is the continuing application of the risk management process throughout the project life cycle. Its purpose is to enhance the probability of project success by increasing the likelihood of improved project performance, thereby decreasing the likelihood of unanticipated cost overruns, schedule delays, and compromises in quality and safety.

Risk is an inherent part of all activities, whether the activity is simple and small, or large and complex. The relative size and/or complexity of an activity may or may not be an indicator of the potential degree of risk associated with that activity.

A key output from the risk analysis effort is the establishment of appropriate contingency/reserves within the project cost estimates and the project schedules at the confidence levels decided upon. A probabilistic approach is essential where a simple algebraic addition of best case underestimates contingency and worst case overestimates contingency.

8.1.2 Scope

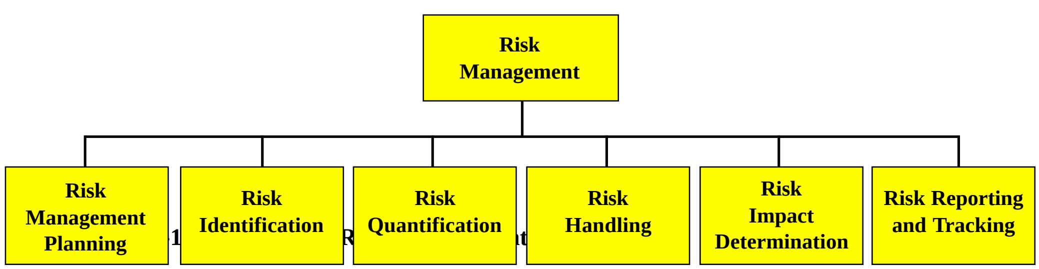
Risk management is the continuing process of planning, identifying, quantifying, responding to, and controlling risks to maximize the potential for the success of an activity. The degree of application of risk management is to be commensurate with a tailored approach, and is a management tool to maximize the results of positive events and minimize the consequences of adverse events.

Risk management is not defined as an Environmental, Safety, or OSHA risk assessment, and consequently, this section does not address the conduct of these specific "safety-type" risk assessments. These independent assessments may, however, provide an input to the risk management process based upon the potential (or likelihood) of events materializing as risks that would increase project cost, cause schedule delays, reduce safety margins, or reduce the quality of the final product.

Risk management can be applied to cost, schedule, technical performance (i.e., risk associated with evolving a new design or approach), programmatic performance (i.e., risk associated with obtaining and using resources that can affect the project), and any other factors important to the management decision process.

Activity success means that the activity is technically feasible, programmatically feasible, and can be completed within an established budget and an established schedule. Conversely, activity failure can result from the failure to meet any of these factors.

Achieving risk reduction is an integral part of setting priorities, sequencing project work, and responding to the most serious risks first. Risk is a dimension of work prioritization and an important (but not the only) consideration in establishing prioritized sequencing of activities and other decision-making processes. The elements of risk management are shown in Figure 8-1.



8.1.3 Different Types of Risk

Numerous types of risk exist. Some examples of risk in different categories are shown in Figure 8-2.

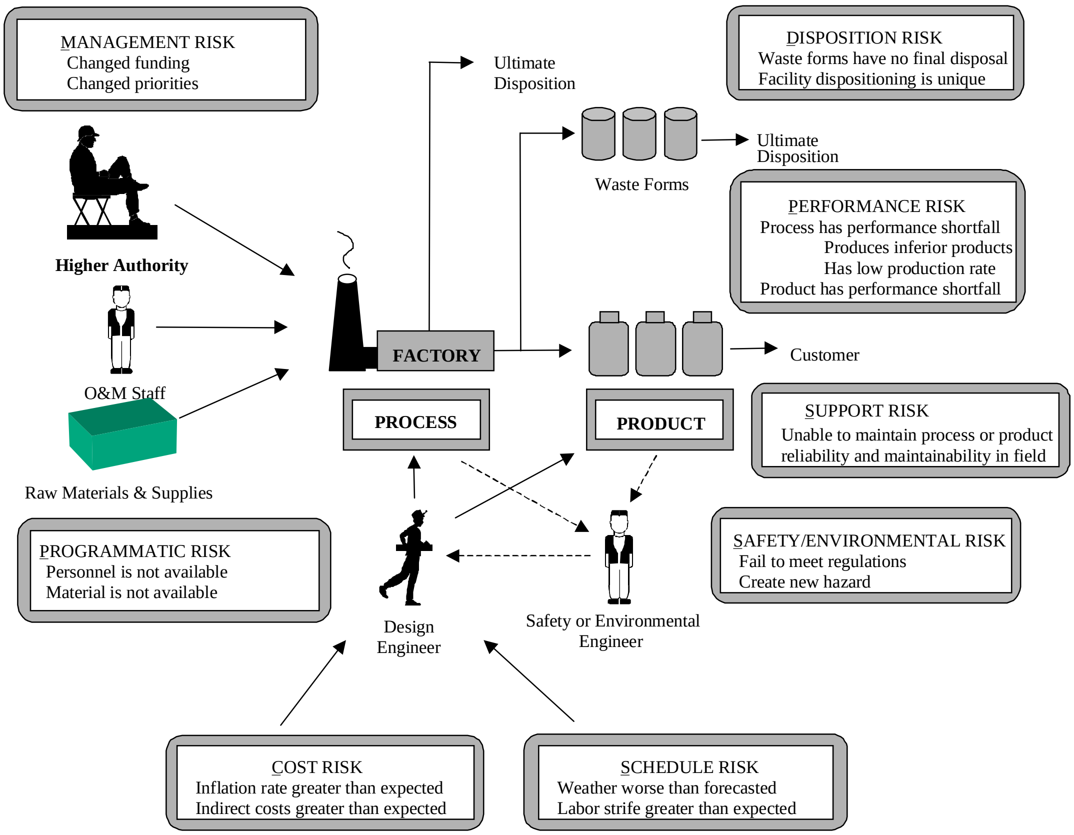


Figure 8-2. Types of Risk

Risks may be grouped or sorted into different categories. The Department of Defense identifies five facets of risk:

- Technical
- Programmatic
- Supportability

- Cost
- Schedule.

The Department of Energy discusses eight facets of risk, but recognizes that safety, environment, disposition, support, and procurement are all technical risks. [3]

- Safety
- Environment
- Disposition
- Support
- Procurement
- Programmatic
- Cost
- Schedule.

The way one chooses to categorize risks is not important as long as the information is used properly. Technical risk is defined as the possible impacts associated with developing a new design or approach either to provide a greater level of performance or to accommodate some new requirements or constraints. Programmatic risk is defined as the possible disruptions caused by decisions, events, or actions that affect project direction, but are outside the manager's control. The combined set of technical and programmatic risks constitutes project risk.

Cost and schedule are unique and treated somewhat differently. They are both types of risk and indicators of project status. This is further complicated because other types of risks will eventually occur in cost and schedule. For example, increasing project scope sometimes resolves performance and design technical problems, thereby increasing cost and/or schedule.

In general, when the risks associated with a project are being evaluated, all aspects of the project should be considered. While there is never a technical risk that does not have a potential impact on cost and/or schedule, the converse is not true. There are a number of cost- and schedule-driven administrative or management factors that do not result from technical issues. While these can also have significant impacts on cost and schedule, they do not need to address technology or design issues.

Any given risk may belong to more than one risk category. For example, a particular piece of equipment may pose a technical challenge and have significant programmatic implications (e.g., not available when needed).

Historically, estimating uncertainties have been included in project cost estimates as “traditional contingency”. It primarily represents uncertainties in the project cost and schedule estimates for the defined work scope that result from:

- Errors and omissions
- Inflation
- Adverse weather
- Pricing variances
- Quantity variances
- Complexity
- Facility access.

For complex projects that involve significant technology development or first-of-a-kind scope/design uncertainties, the traditional contingency models may not be adequate. For these projects, a systematic technical programmatic risk analysis methodology may be used for evaluating needed contingency. This contingency includes the possible impacts from technical and programmatic types of risk. In addition, the actions resulting from risk response/risk handling strategies are included in project baseline scope and cost estimate.

8.1.4 RELATIONSHIP TO SYSTEMS ENGINEERING

The risk management process is a part of the overall systems engineering approach to definition of objectives and evaluation of solutions to problems as shown in Figure 8-3.

The approach consists of four steps that are performed in a logical sequence, supported by three additional process control activities that are performed concurrently with each of the sequential process steps. Risk management is one of the

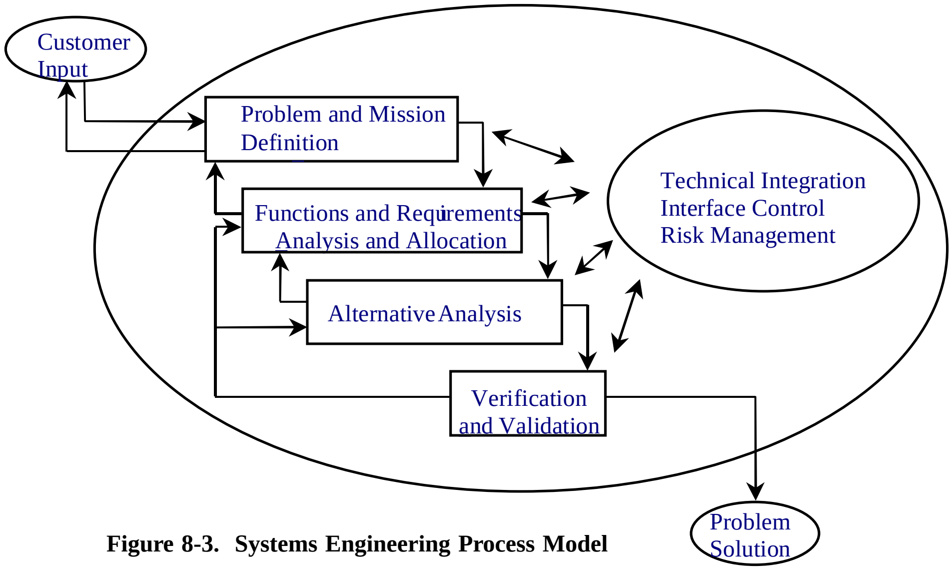


Figure 8-3. Systems Engineering Process Model

process control activities that are performed in each step. The systems engineering approach can be applied to problems and activities at all levels (e.g., project level, system level, component level) and of all types (e.g., physical design, organizational change, problem resolution) where change is needed.

Applications generally involve iterative implementation of the process starting at the top-level mission statement and progressing through increasing levels of detail. Each step of the process is performed before repeating the process for the next level of detail.

For additional information on the systems engineering approach, refer to Practice 13, System/Value Engineering.

8.2 Risk Management Process Steps and Methodology

The following sections provide a detailed description of the six steps in the process and describe at least one approach or methodology. The Risk Management Functional Flow Diagram, which shows the interrelationship among the six major risk management process elements, is shown in Figure 8-4.

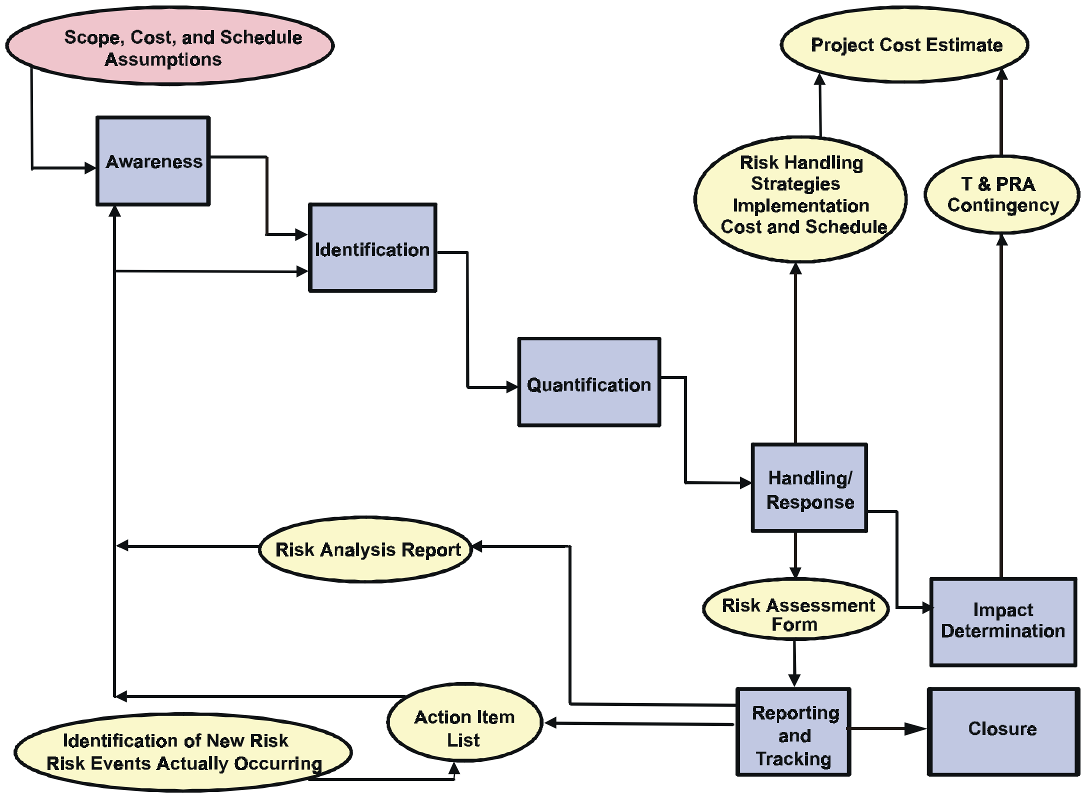


Figure 8-4. Risk Management Functional Flow Diagram

8.2.1 RISK MANAGEMENT PLANNING

Prior to initiation of risk management, an activity is evaluated to determine if there is a potential for risk in the proposed or defined baseline (scope, schedule, and cost). This determination is not always simple to accomplish in that all activities contain risk. In many cases, however, this risk is judged to be low enough that existing limited controls required to manage the scope, schedule, and costs are adequate, and that no special attention is required for any particular potential risk occurrence.

8.2.1.1 Risk Screening

To facilitate the activity evaluation process, the activity manager reviews the activity against a set of criteria designed to lead than through a concise but comprehensive risk screening. An example of a criteria, set in the form of a questionnaire is provided in Table 8-1. In cases where an identified criterion/criterion question does not apply, the *No* response is obvious. For situations where the potential risk is judged to be *Low* (or acceptable), as described above, the basis for that evaluation may not be clear. In such cases, there is merit in documenting the rationale used in making this determination since the information may be valuable in supporting a decision as to whether or not the risk management process should be applied.

In all cases, the activity is first screened for the need to apply project controls as required by project management procedures. This is accomplished by calibrating the activity with respect to such issues as size, organizational interfaces, and political visibility via evaluation of Part B of the checklist. This evaluation, as distinct from the remainder of the risk management process, while indicating a level of project control has no bearing on the remainder of the risk management process.

Once the level of project control is determined, Part A of the checklist is evaluated for the potential for *Yes* technical risks. If all answers are *No* or *Low (acceptable)*, the process is complete and no risk management is required. If any answers are *Yes*, then the risk management process is initiated by moving to the next step (i.e., preparation of a risk management plan).

Table 8-1. Risk Screening Guidelines

Screenings are performed to determine if the project or activity has the potential for risk. Judgement must be exercised in determining whether the screening item results in a potential risk. Categories that pose *No* risk to the project are identified as such. A *Low* risk is marked accordingly and should be justified under separate documentation. A *Yes* response indicates the potential for risk. If any of the questions are answered as *Yes*, a Risk Analysis is required.

Part A: Technical Risk Screening Criteria	**Potential for Risk?**		
	No	**Low**	**Yes**
TECHNOLOGY			
1. New technology?			
2. Unknown or unclear technology?			
3. New application of existing technology?			
4. Modernized/advanced technology in existing application?			
PHYSICAL INTERFACES / INTERFACE CONTROL			
1. Multiple system interfaces?			
2. Multiple technical agencies?			
3. Interface with operating structures, systems, or components during installation?			
SAFETY			
1. Criticality potential?			
2. Significant exposure/contamination potential?			
3. Any impact to the Facility's Authorization Basis?			
4. Hazardous material involved?			
5. Process hazard potential?			
6. Will hazardous materials inventories exceed the OSHA or Radiation Management Plan total quantities?			
REGULATORY/ENVIRONMENTAL			
1. Environmental assessment/impact statement required?			
2. Additional releases?			
3. Undefined disposal methods?			
SAFEGUARDS AND SECURITY			
1. Category I nuclear material? (DOE Orders require formal Vulnerability Assessment)			
2. Classified process / information? (DOE Orders require Security Risk Assessment)			
DESIGN			
1. Undefined, incomplete, or unclear functional requirements?			
2. Undefined, incomplete, or unclear design criteria?			
3. Complex design features?			
4. Difficult to perform functional test?			
5. Numerous or unclear assumptions?			
RESOURCES / CONDITIONS			
1. Adequate and timely resources not available?			
2. Specialty resources required?			
OTHER (Define below)			
1.			
2.			

Table 8-1. Risk Screening Guidelines (cont.)

Part B: Project Risk Screening Criteria	**Potential for Risk?**		
	No	**Low**	**Yes**
COST			
1. Is the modification TPC greater than $4M?			
SCHEDULE			
1. Project Schedule uncertainties or restraints that may impact project completion or milestone dates?			
PROCUREMENT			
1. Long-lead items that may affect critical path?			
2. Potential unavailable qualified vendors or contractors?			
PROGRAMMATIC INTERFACES			
1. Significant transportation or infrastructure impacts?			
2. Multiple project interface?			
3. Multiple contractor interface?			
4. Significant interface with operational facility?			
REGULATORY/ENVIRONMENTAL			
1. Political visibility? (DOE, local government, Congress)			
OTHER (Define below)			
1.			
2.			

8.2.1.2 Risk Management Plan

If required, a risk management plan should be developed at the onset of a project. This plan is a living document used throughout the life of the project and should therefore be under configuration management. The plan should identify project mission and description, project assumptions, responsibilities for risk management, and a description of the risk management process that will be followed—including the procedures, criteria, tools, and techniques to be used to identify, quantify, respond to, and track project risks. Inherent in the project description should be the identification of issues/exceptions with standardized practices and procedures, such as:

- Unusual heat stress or exposure to cold situations
- New or atypical traffic pattern requirements
- Nonstandard methods for compliance with OSHA
- Deviations from standard construction practices
- Requirements that could alter standard job plans or maintenance activities
- Limited access to medical facilities
- Work involving confined spaces, scaffolding, ladders, etc., where current site practices are lacking.

These issues should be documented to facilitate identification of any risks associated with them, as opposed to identification of tasks that can readily be defined and costed as part of the project scope and baseline. While all applicable industry and site safety, operations, and maintenance documents provide input to facilitate risk identification, subject matter experts are generally the best source of information.

A risk management plan should also identify when, during the project life cycle, the risk analysis (identification, quantification, and response) will be performed and updated. The level of detail in the plan, and the scope, timing, and level of risk analysis should be commensurate with the complexity of the project. Risks that are identified and quantified as low should have minimal follow-on activities. The outline of a typical Risk Management Plan is shown in Table 8-2.

Table 8-2. Risk Management Plan Outline (Typical)

1.0 INTRODUCTION
1.1 Risk Management History for this Activity
1.2 Risk Management Purpose and Scope Summary
1.3 Scope Limitations
2.0 ACTIVITY (e.g., PROJECT, PROGRAM, OR TASK)
2.1 Background
2.2 Assumptions
2.3 Structure for Risk Analysis
2.4 Risk Management Team
2.5 Responsibilities for Risk Management
3.0 RISK MANAGEMENT PROCESS EXECUTION
3.1 Risk Management Planning
3.2 Risk Identification
3.3 Risk Quantification
3.4 Risk Handling
3.5 Risk Impact Determination
3.6 Risk Tracking, Reporting, and Closure
4.0 REFERENCES
5.0 APPENDICES
5.1 Risk Screening Typical Risk Management Data Tracking
5.2 Risk Assessment Form and Instructions
5.3 Guidelines for Conduct of Risk Management Activities
5.4 Typical Risk Management Data Tracking

For most projects, risk management is not a one-time activity or project event; it is a continuing process. Risk analyses will occur several times in the project life cycle. Often a preconceptual risk analysis is conducted to facilitate alternative evaluations, determine the level of project management planning required, and the level of technical information and development activity appropriate to the project. Risk analysis for a project is typically performed and updated during each of the life-cycle phases of the project. Periodic reviews of the risk analysis should be performed to identify new risks and to evaluate changes during the project implementation cycle.

The project manager is responsible for the development of a risk management plan with key team personnel input and buy-in described above. This plan will document the strategies and procedures that will be used to manage project risk. Rather than a separate plan, it may be included as a section in the overall Project Execution Plan.

8.2.1.3 Selection of Assessable Elements

Assessable elements are discrete entities against which an effective risk analysis may be performed and the results evaluated to provide the input needed to make necessary decisions. Dividing an activity, project, or program into smaller more manageable elements enables the identification of risks in a structured manner.

For example, in attempting to evaluate the risk associated with two different alternatives available to baseline a project design, the assessable elements might be "Alternative 1" and "Alternative 2". Similarly, in evaluating manufacturing a new widget, assessable elements might be the Product "Widget" and the Process "Manufacturing Facility". If the project involves design, construction, and operation of a facility, the assessable elements can be the various functions or groupings of functions (i.e., systems, subsystems, or functions). It can also be based on the various elements in the Work Breakdown Structure (WBS) for the project. Table 8-3 provides guidance in the selection of appropriate assessable elements for a project. Note that there is no right or wrong selection; some elements are simply more conducive to future activities than others. In situations where multiple risk assessments are conducted for the same project, it is not necessary that the same assessable elements be used each time. In fact, it is most likely that the selection of assessable elements will change throughout the project's life cycle.

Table 8-3. Guidance For The Selection Of Assessable Elements

► Individual Alternatives—useful for "new mission" or "new facility" activities with multiple potential alternatives, or to assist in down-selecting to the best or better alternatives as a part of an alternative study.
► Product/Process Components—useful when the facility's deliverable is clearly distinct from the facility.
► Distinct Functions or Groupings of Functions (e.g., facility or a system)—useful when the functions have readily identified risks or grouping have been readily defined.
► WBS Allocation—useful when the project is in final design stage.

8.2.2 RISK IDENTIFICATION

Risk identification is an organized approach for determining which events are likely to affect the activity or project, and documenting the characteristics of the events that may happen with a basis as to why this event is considered a risk. Identification relies on the skill, experience, and insight of project personnel and subject matter experts, as well as the project manager. Subcontractor participation in the identification process may be desirable and useful. Risks should be identified that are both internal (under project control) and external (beyond project control).

Once risk areas have been identified, risk identification proceeds by clearly documenting what risks are foreseen in each area. This includes not only the issue or event, but specifically why this concern is an assessable risk to the project.

Whereas risk is generally considered in terms of negative consequences (e.g., harm or loss) in the project context, it is also concerned with opportunities that result in positive outcomes. Therefore, risk identification may be accomplished through cause and effect evaluation that indicates whether an outcome should be avoided or encouraged.

Key sources of input to risk identification include:

- *Activity or Project Descriptions (Scope Statements, etc.).* The nature of the project will have a major effect. For example, a project involving proven technology may have significantly less risk when compared to a project involving new technology, which may require extensive development and thus have a higher risk.

- *Other Activity or Project Planning Documents.* The WBS may provide visibility into new innovations not readily extracted from scope statements, statements of work (SOWs), etc. Cost and/or time estimates may provide greater risks when developed from early or incomplete information. Procurement plans may identify unusual market conditions such as regional sluggishness or lack of multiple suppliers. Finally, the end user and the design agency may develop hazard lists that identify additional sources of risk.

- Historical Information—This information can be extracted from previous project files, personal remembrances, the Estimating Department, and commercial databases. Lessons learned can also provide input.

Methods and tools for initiating identification of risk can vary, depending upon the resources (project documentation, experience with similar projects, lessons learned, knowledgeable personnel, etc) available. Risk identification can be initiated by using risk source checklists (including categories for both technical and programmatic risks), process flow charts, risk/activity templates, interviews with subject matter experts, and team brainstorming. The tools are intended to both stimulate the thought process of the Risk Analysis Team and supplement their knowledge regarding potential risks.

Table 8-4 illustrates a typical checklist of risk categories. In using these checklists, the Risk Analysis Team evaluates each assessable element, one-by-one, against each item in the risk category list, to determine whether anything in the project presents a risk. The process continues until the entire checklist has been considered. While the use of a template is similar to that of a checklist, using a process flowchart helps to bring about a better understanding of each step in a scenario and the interrelationships between steps. This type of evaluation considers each of the steps involved in the process, one at a time, to determine the potential that the step includes any risks. This method is most useful when new or modified process steps are involved.

The results of the risk identification step are clear statements of risk with corresponding bases. The event that creates the risk will be identified, as well as the affect the event could have on the project or activity. This information should be documented in Section A of the Risk Assessment Form shown in Table 8-5. The other parts of this form will be addressed in subsequent sections of this document. Table 8-6 contains line-by-line instructions for completing the risk assessment form.

Table 8-4. Risk Category List

Design	**Technology**
• Undefined, Incomplete, Unclear Functions or Requirements	• New Technology
• Complex Design Features	• Existing Technology Modified
• Numerous or Unclear Assumptions or Bases	• New Application of Existing Technology
• Reliability	• Unknown or Unclear Technology
• Inspectability	**Procurement**
• Maintainability	• Procurement Strategy
• Safety Class	• First-Use Subcontractor/Vendor
• Availability	• Vendor Support
• Errors and Omissions in Design	**Construction Strategy**
Regulatory & Environmental	• Turnover/Start-Up Strategy
• Environmental Impact Statement Req'd. (EIS)	• Direct Hire/Subcontract
• Additional Releases	• Construction/Maintenance Testing
• Undefined Disposal Methods	• Design Change Package Issues
• Permitting	**Testing**
• State Inspections	• Construction
• Order Compliance	• Maintenance
• Regulatory Oversight	• Operability
Resource/Conditions	• Facility Startup
• Material/Equipment Availability	• System Startup (Subcontractor or PE&CD)
• Specialty Resources Required	**Safety**
• Existing Utilities Above and Underground	• Criticality Potential
• Support Services Availability	• Fire Watch
• Geological Conditions	• Exposure Contamination Potential
• Temporary Resources (Power, Lights, Water, etc.)	• Authorization Basis Impact
• Resources not Available	• Hazardous Material Involved
• Construction Complexities	• Emergency Preparedness
- Transportation	• Safeguards & Security
- Critical Lifts	• Confinement Strategies
- Population Density	**Interfaces**
• Escorts	• Multiple Agencies, Contractors
• Personnel Training & Qualifications	• Special Work Control/Work Authorization Procedures
• Tools, Equipment Controls, & Availability	• Operating SSCs Including Testing
• Experience with System/Component (Design,	• Multiple Customers
Operations, Maintenance)	• Co-Occupancy
• Work Force Logistics	• Outage Requirements
• OPC Resources	• Multiple Systems
- Operations Support	• Radiological Conditions (Current and Future)
- Health Physics	- Contamination
- Facility Support	- Radiation
- Facility Maintenance Centralized Maintenance	• Multiple Projects
- Construction Support Post Modifications	• Proximity to Safety Class Systems
• Training	**Management**
• Research and Development Support	• Funding Uncertainties
• Multiple Project/Facility Interface	• Stakeholders Program Strategy Changes
• Facility Work Control Priorities	• Errors and Omissions in Estimates
• Lockout Support	• Fast Track/Critical Need
Safeguards & Security	• Infrastructure Influence
• Catetgory I Nuclear Materials	
• Classified Process/Information	

Table 8-5. Risk Assessment Form

Risk Assessment Form

Risk Identification No.: *00-00002*

Assessed Element (Optional):

Risk Title:

KASE # (Optional):

Risk Category (Optional):

Risk Type (Optional):

Date:

Responsibility (Optional):

A. Statement of Risk: *(State Event and Risk)*

B. Probability: *(State the probability and basis that the risk will come true without credit for RHS)* P= ______

O Very Unlikely(VU) (P ≤ 0.1) O Unlikely(U) (.2 ≤ P ≤ 0.4) O Likely(L) (.5 ≤ P ≤ 0.7) O Very Likely(VL) (.8 ≤ P ≤ 1.0)

C. Consequence: *(State the consequences and quantify basis if that risk comes true without credit for RHS)* C= ______

Worst Case Cost Impact: ______ Worst Case Schedule Impact: ______

O Negligible(N) (C ≤ 0.1) O Marginal(M) (.2 ≤ C ≤ 0.4) O Significant(S) (.5 ≤ C ≤ 0.7) O Critical(C) (.8 ≤ C ≤ 0.9) O Crisis(Cr) (C > 0.9)

D. Risk Level: O Low(L) O Moderate(M) O High(H) Probability x Consequence = Risk Factor (optional): ______

E. Risk Handling Strategies:

Risk Handling Approach	Risk Handling Strategy (RHS) Description and Bases	Reduced			Implementation		Tracking# (Optional)
		Prob.	Cons.	Risk	Cost	Schedule	

F. Residual Risk Impact: Cost Consequence: ______ ______ ______
Schedule Consequence: ______ ______ ______
Best Most Likely Worst

G. Description of Residual Risk:

H. Schedule to Cost Conversion Factor: $ ______ per unit ______

I. Affected WBS:

J. Additional Comments (optional):

Unclassified ONLY

Table 8-6. Typical Risk Assessment Form Instructions

Line A	Provide a clear statement of the risk.
Line B	Identify the probability of occurrence of the risk in a qualitative or quantitative manner. This line also should indicate the basis for arriving at the probability value
Line C	Identify the consequence of occurrence of the risk in a qualitative or quantitative manner. This line also should indicate the basis for arriving at the consequence value. The (worst case) cost and the schedule impact if the consequence is realized is also identified.
Line D	Identify the risk level and calculate the risk factor (if quantitative).
Line E	Identify the risk handling strategies (both preferred and a backup strategy, if any), and document the impact of the handling strategy on the risk. The new probability and the consequence values are identified for the residual risk. The cost and duration for the implementation of these strategies are also identified.
Line F	Identify the impact of the reduced consequence on the total cost as determined in terms of the best, expected, and worst case cost estimates.
Line G	Provide a description of the residual risk in terms of anticipated work/rework.
Line H	Identify a cost per unit time of delay (i.e., "hotel load cost").
Line I	Identify the WBS element that would be affected by realizing the stated risk. This can be labor and/or equipment items.
Line J	Provide any additional comments that may apply to the risk, in any of the other line entries.

8.2.3 Risk Quantification

Risk quantification involves determining the probability of the occurrence of a risk, assessing the consequences of this risk, and combining the two (probability and consequence) to identify a "risk level." This risk level represents a judgment as to the relative risk to the project as a whole and is categorized as *Low*, *Moderate,* or *High*. Based on the risk level, handling strategies are identified to respond to the risk.

A number of factors complicate this analysis including:

- A single risk event can cause multiple effects on a number of systems (ripple effect).
- Opportunities for one participant may be considered detrimental by another.

- Mathematical techniques can cause false impressions of precision and reliability, i.e., results may only be indicators, not absolute measures.

Risk quantification may be performed *quantitatively* or *qualitatively*, depending upon the project complexity and the preference of the analysis team. The end result is the same in both cases.

Risk level determination can be done using a variety of techniques. This can be done by determining the probability of the risk occurring and its consequence(s). The probability of a risk occurring is usually a number or a grade and has no units (dimensionless). However, consequences are usually measured in specific units such as cost, exposure rates, or casualty rates. In the methods described below, criteria are defined and used to convert the consequence(s) into a unitless number or grade. Later, the impact of risk on a project or activity is defined using units of cost.

Table 8-7 shows typical criteria for defining probabilities and Table 8-8 shows typical criteria for defining consequences. These probability and consequence tables are used with both the qualitative and quantitative methods of risk quantification discussed below. The criteria followed by asterisks in these tables must be calibrated relative to the project. For example, the consequence definitions of *Negligible*, *Marginal*, *Significant*, *Critical*, and *Crisis* may vary considerably from a small to a large project.

Table 8-7. Risk Probabilities (Typical)

Probability of Occurrence		Criteria
Qualitative	**Quantitative**	
Very Unlikely	< 0.1	Will not likely occur anytime in the life cycle of the facilities; or the estimated recurrence interval exceeds 10,000 years*; or the probability of occurrence is less than or equal to 10%.
Unlikely	> 0.1 but < 0.4	Will not likely occur in the life cycle of the project or its facilities; or estimated recurrence interval exceeds 1000 years*; or the probability of occurrence is greater than 10% but less than or equal to 40%.
Likely	> 0.4 but < 0.8	Will likely occur sometime during the life cycle of the project or its facilities; or estimated recurrence interval is between 10 to 1000 years*; or the probability of occurrence is greater than 40% but less than 80%.
Very Likely	> 0.8	Will likely occur sometime during the life cycle of the project; or estimated recurrence interval is less than 10 years*; or the probability of occurrence is greater than or equal to 80%.

*Time intervals to be customized per needs specific to the modification being assessed.

Table 8-8. Risk Consequences (Typical)

Consequence of Occurrence		Criteria[1]
Qualitative	Quantitative	
Negligible	< 0.1	Minimal or no consequences; unimportant. Some potential transfer of money, but budget estimates not exceeded. Negligible impact on program; slight potential for schedule change; compensated by available schedule float.
Marginal	0.2 to 0.4	Small reduction in modification/project technical performance. Moderate threat to facility mission, environment, or people; may require minor facility redesign or repair, minor environmental remediation, or first aid/minor medical intervention. Cost estimates marginally exceed budget.[2] Minor slip in schedule with some potential adjustment to milestones required.[2]
Significant	0.5 to 0.7	Significant degradation in modification/project technical performance. Significant threat to facility mission, environment, or people; requires some facility redesign or repair, significant environmental remediation, or causes injury requiring medical treatment. Cost estimates significantly exceed budget.[2] Significant slip in schedule with resulting milestones changes that may affect facility mission.[2]
Critical	0.8 to 0.9	Technical goals of modification/project cannot be achieved. Serious threat to facility mission, environment, or people; possibly completing only portions of the mission or requiring major facility redesign or rebuilding, extensive environmental remediation, or intensive medical care for life-threatening injury. Cost estimates seriously exceed budget. Excessive schedule slip unacceptably affecting overall mission of facility/site/DOE objectives, etc..
Crisis	> 0.9	Modification/project cannot be completed. Cost estimates unacceptably exceed budget. Catastrophic threat to facility mission, environment, or people; possibly causing loss of mission, long-term environmental abandonment, and death.[2]

[1] Any one or more of the criteria in the five levels of consequence may apply to a single risk. The consequence level for the risk being evaluated must be based upon the highest level for which a criterion applies.

[2] Actual dollar values and schedule delays to be determined, per the needs/limitations of the modification being assessed.

Special attention must be given to first-of-a-kind risks because they are often associated with project failure. First-of-a-kind risks should receive a critical or crisis consequence estimate unless there is a compelling argument for a lesser consequence value determination.

The output of the risk quantification process is a determination of the probability of occurrence, the consequence of occurrence, and the risk level for each risk. This information is documented in Sections B, C and D of the Risk Assessment Form shown in Table 8-5. The risk quantification method chosen must be able to provide this risk level based upon the judgment exercised in the analysis process and be consistent with the implementing organization's procedures. Numerous methodologies can be employed to quantify risk. Whatever method is used, documentation of the chosen methodology is recommended. Documentation creates a record for future use in the event that a new team performs a later review, revision, or update.

The two methods developed further in this section include:

- Qualitative—based upon the intersection of the qualitative probability and consequence values derived from Tables 8-7 and 8-8, respectively, using the Risk Level Matrix shown in Figure 8-2.
- Quantitative—based upon the product of the quantitative probability and consequence values derived from Tables 8-7 and 8-8, respectively.

8.2.3.1 Qualitative Approach (Risk Level Matrix)

This method begins by assigning qualitative values to event probability and consequence(s) that will then be used to determine a qualitative risk factor. The following steps provide the details of the method. The key features of this method are that it:

- Allows independent assessment of the probability and consequence of a risk
- Provides qualitative definition of basis for the risk and risk level.

The qualitative methodology uses the risk level matrix shown in Figure 8-5.

Steps:

1. Address each risk statement from the risk assessment form individually.
2. Determine the qualitative probability of occurrence value (P) for each risk with appropriate basis and justification. The probability of occurrence is for the duration of all project phases or for the activity being assessed. Table 8-7 provides typical criteria for establishing probability values.
3. Determine the qualitative consequence of occurrence value (C) for each risk with appropriate basis and justification. The consequence of occurrence is for the duration of all project phases or for the activity being assessed. Table 8-8 provides typical criteria for establishing consequence values.

Assign a risk level based upon the intersection of the qualitative P and C values on the 5x4 risk level matrix in Figure 8-5. Depending upon the activity and the ability to differentiate the risk levels, other matrices may be chosen by the risk analysis team.

Probability of Risk Materializing	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	High
	Severity of Consequence				

Figure 8-5. Risk Level Matrix

8.2.3.2 Quantitative Approach (Probability x Consequence Equation)

This method begins by assigning quantitative values to event probability and consequence(s) that will then be used to determine a quantitative risk factor. The details of this method are outlined below. The key features of this method are that it:

- Provides qualitative definition of basis for the risk, but quantitative inputs for risk level
- Provides finer grading within the risk levels.

This method is useful for prioritization activities, either among alternatives where numerous risks exist within the individual risk levels, or among risks in determining where to allocate resources.

The quantitative methodology uses the Probability x Consequence Equation

RF = (Px C), where:

RF = Risk Factor
P = Probability of Occurrence
C = Consequence of Occurrence

Steps:

1. Address each risk statement from the risk assessment form individually.
2. Determine the quantitative probability of occurrence (P) for each risk with appropriate basis and justification. The probability of occurrence is for the duration of all project phases or for the activity being assessed. The probability is expressed as a decimal between 0 and 1, where 0 is no probability of occurrence and 1 is 100% probability of occurrence. Table 8-7 provides typical criteria for establishing probability values.
3. Determine the quantitative consequence of occurrence (C) for each risk with appropriate basis and justification. The consequence of occurrence is for the duration of all project phases or for the activity being assessed. The consequence is expressed as a decimal between 0 and 1. Table 8-8 provides typical criteria for establishing consequence values.
4. Using the formula RF = P x C, determine the risk factor for each identified risk.
5. Based on the following values, determine the risk level for each identified risk.

   High Risk - RF is greater than 0.4[1]

   Moderate Risk - RF is greater than 0.1, but less than or equal to 0.4

   Low Risk - RF is less than or equal to 0.1

[1] This threshold ensures that risks with a mid-range (0.6) probability of *Likely* and a high-end (0.7) consequence of *Significant* (and vice-versa) will be classified as *High* risks.

8.2.3.3 Other Risk Quantification Methods

Expected monetary value, expert judgement, simulation, and the use of decision trees are other risk quantification methods that may be used.

Expected monetary value is the product of the risk event probability multiplied by the value of the gain or loss that will be incurred. Schedule impacts and intangibles (i.e., a loss may put the organization out of business) must be considered when using this approach.

Expert judgment is often used in lieu of, or in conjunction with, mathematical techniques. For example, risk events could be described as having a very likely, likely, unlikely, or very unlikely probability of occurrence and a crisis, critical, significant, marginal, or negligible impact or consequence. Based on these descriptions, the risk level matrix shown in Figure 8-5 can be used.

Simulation uses a model of a system process such as the project schedule to simulate a project using Monte Carlo analysis to "perform" the project many times so as to provide a statistical distribution of calculated results. The use of Monte Carlo analysis to estimate the risk cost distribution by statistically combining risk costs is illustrated in Section B.3.5.

A decision tree is a diagram depicting key interactions between decisions and associated change events as understood by the decision-maker. This approach helps the analyst to divide a problem into a series of smaller, simpler, and more manageable events that more accurately represent reality to simplify decision-making.

8.2.4 RISK HANDLING

Risk handling is the identification of the course of action or inaction selected for the purpose of effectively managing a given risk. **All identified risks shall be handled.** Risk-handling methods should be selected after personnel have determined the probable impact on the project, so that handling strategies are selected that identify the optimum set of steps to balance risk with other factors, such as cost and timeliness. Responses to risks generally fall into one of four major categories (reduce or mitigate, accept, avoid, or transfer) shown in Figure 8-6 and are described in greater detail in the subsections that follow.

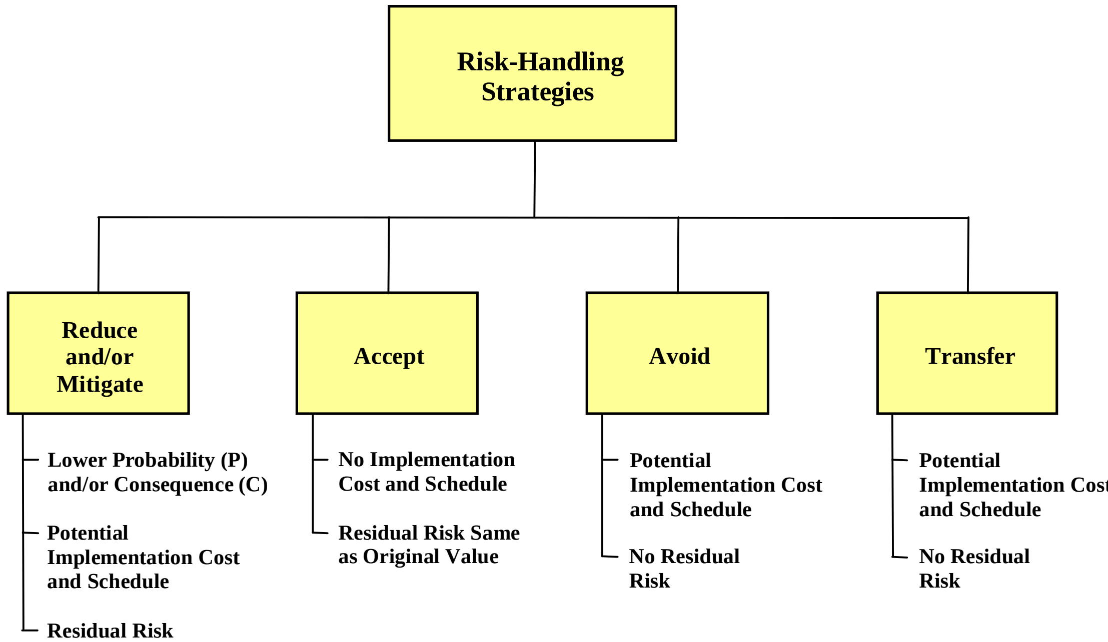


Figure 8-6. Risk Handling Strategies

The selected handling strategy, or strategies, should be documented in Sections E, F, G, and H of the Risk Assessment Form shown in Table 8-5. Costs related to the scope of the selected risk handling strategies are added to the project baseline cost and incorporated in project action items. Thus, risk handling implementation costs are included in the baseline cost.

8.2.4.1 Reduce and/or Mitigate

This strategy identifies specific steps or actions, which will increase the probability that an activity will succeed, or, conversely, reduce the probability of the occurrence of the risk or mitigate the consequence of a risk. The expected outcome of a risk event can be reduced by lessening the probability of occurrence, e.g., by using proven technology to lower the probability that the project will not work, or by reducing the risk outcome by adding specific mitigation actions and any corresponding cost implementation and schedule to the project scope. Using this strategy, the risk remains, but at a reduced level. This reduced level is called the residual risk. This residual risk will be statistically combined later with other residual risks to develop risk contingency.

If the strategy is to reduce and/or mitigate the risk, then the cost and duration to implement that strategy is determined and documented on the risk assessment form. In addition, the probability, the consequence, and the risk factor and level of the residual risk (i.e., risk after reduction and/or mitigation) are then determined. The potential cost and schedule impact of the residual risk is identified using three types of estimates: the best case (or most optimistic), the most likely, and the worst case (or most pessimistic) estimate for establishing the cost distribution probability for Monte Carlo simulations.

8.2.4.2 Accept

Accepting a risk is essentially a "no action" strategy. Selection of this strategy is based upon the decision that it is more cost effective to continue the project as planned with no resources specifically dedicated to addressing the risk. However, the "no action" strategy may be hedged by developing a contingency plan in case the risk event occurs and then tracking the risk to assure that it does not increase during project execution. Low risks are typically accepted.

For a handling strategy of *accept*, the residual risk equals the initial risk because this strategy does not change the risk level. The residual risk will be statistically combined with other residual risks to develop contingency. If the risk is accepted without additional actions, then the cost and duration of implementation is zero, which is documented on the risk assessment form. The potential cost and schedule impact of the risk is identified using three types of estimates: the best case (or most optimistic), the most likely, and the worst case (or most pessimistic) estimate for establishing the cost distribution probability for Monte Carlo simulations.

8.2.4.3 Avoid

This strategy focuses on totally eliminating the specific threat or risk-driving event usually by eliminating the potential that the risk event can occur. This can be accomplished through total structure, system, or component redesign, or by selecting an alternate design approach, that does not include the particular risk. The project will not be able to eliminate all risks, but specific risk events can often be eliminated with this strategy.

If the strategy is to avoid the risk, the cost and duration of implementation of the strategies is determined and documented. Once the strategy is implemented, the risk level for the specific element will be reduced to zero. No residual risk remains with this strategy.

8.2.4.4 Transfer

This strategy is used when a project scope with identified risks can be transferred to another project or entity, especially when this same risk can be more easily handled within the receiving project or entity. A risk can be transferred to an outside organization by purchasing services to obtain technology outside of the project. This in itself is a risky strategy in that the vendor can go out of business or fail to meet the agreed requirements, leaving the project with the same initial problem. In any case, the individual or organization receiving the risk must accept the risk transfer.

If the strategy is to transfer the risk, the cost and duration of implementation of the strategies is determined and documented. Once the strategy is implemented, the risk level for the specific element will be reduced to zero. No residual risk remains with this strategy.

8.2.5 Risk Impact Determination

Risk impact determination is the process of evaluating and quantifying the effect of risk(s) on the project. Risk impacts a project in two different ways:

- Handling strategy implementation, which must be reflected in a revised project baseline
- Residual risk, which must be reflected in project contingency.

The ultimate impact of risk management is to increase the probability of project/activity success by focusing attention on problem areas early and reducing the amount of costly rework in the future. For each and every risk, there is potential cost or schedule impact if the risk occurs. The impacts of these risks on cost and schedule must be addressed in the project estimates.

8.2.5.1 Handing Strategy Implementation

The first impact is the handling strategy implementation, which must be included in the project cost and schedule baseline. If the risk is reduced using a risk reduction or mitigation strategy, there may be a cost and schedule impact associated with the implementation of that strategy as shown in Figure 8-7. The “implementation” cost and schedule impacts of the risk mitigation strategy must be included in the baseline project cost and schedule.

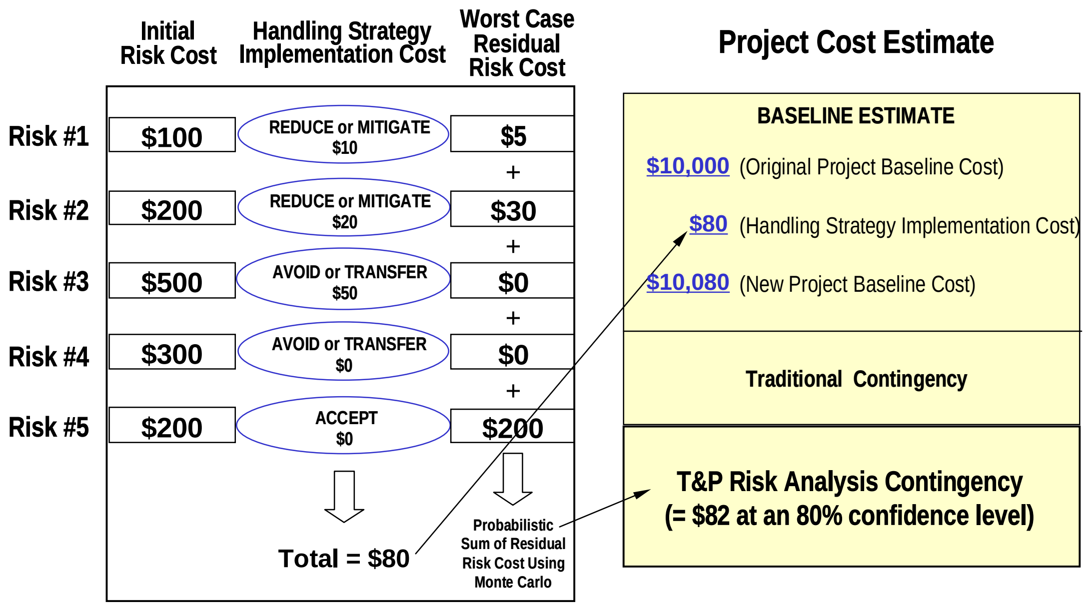


Figure 8-7. Risk Impact Determination Reflected in Project Cost Estimate

8.2.5.2 Residual Risks

Even after risk-handling strategies have been implemented, there may be remaining risk impacts, which are referred to as residual risks. The cost and schedule impacts of residual risks must be included in the contingency calculations. This is accomplished by determining a cost and/or schedule impact probability distribution for each residual risk. These probability distributions are then combined statistically through a Monte Carlo process to produce the contingency estimate. For the example shown in Figure 8-7, the contingency is $82 (at an 80 percent confidence level), significantly less than the $235 algebraic sum of the worst case residual risk costs.

Figure 8-8 illustrates the impact of risk handling on cost in another example. The initial risk cost prior to handling is $48.630 million. The handling implementation cost is $1.989 million, and the residual risk contribution to the project contingency, using the Monte Carlo process at an 80% confidence level, is $7.371 million.

The remainder of this section provides greater detail on the analysis of cost impacts from risks and the use of an approach to determine the risk impact on schedule.

TSF Risk-Based Cost Contingency

Risk Item / Basis	Before Handling: Risk Level	Before Handling: Worst Case Cost ($K)	Handling Strategy	Cost to Implement Handling	After Handling: Risk Level	Residual Risk Cost Estimates ($K): Best Case	Residual Risk Cost Estimates ($K): Most Likely	Residual Risk Cost Estimates ($K): Worst Case
Redesign to solve problems identified during reviews	Moderate	3,360	Mitigate	75	Low	0	150	500
Do analyses/design 105 per external comments	Moderate	390	Avoid	0	---	N/A	N/A	N/A
Rework design documents during concept evolution	Moderate	5,720	Mitigate	0	Moderate	0	750	2,500
Redesign for add'l equipment for ops/pretreat. interface	Moderate	160	Mitigate	0	Low	0	40	100
Design for cintering equipment	High	500	Mitigate	308	Moderate	0	0	200
Redo design for SNF re-sizing	Moderate	200	Accept	0	Moderate	0	50	200
Redesign; contamination control in process room	Moderate	5,000	Mitigate	361	Moderate	0	300	3,000
Change design basis, due to scale-up impact	Low	50	Accept	0	Low	0	15	50
Redesign, for SC furnace	Low	800	Mitigate	0	Low	0	0	50
Redesign to add gas-trapping system	Low	1,550	Accept	0	Low	0	0	1,550
Rework to add waste streams to design	High	3,000	Mitigate	0	Moderate	0	250	2,300
Rework robotic features design	High	7,440	Mitigate	53	Moderate	0	500	2,000
Redesign for characterization	High	5,000	Mitigate	176	Moderate	0	600	3,000
Redesign to meet requirements of DOE canisters	Moderate	3,000	Reduce	0	Moderate	0	100	3,000
Design for new cables	Moderate	400	Mitigate	0	Low	0	0	50
Redesign for additional MC&A equipment	Moderate	400	Mitigate	0	Low	0	0	50
Redesign, to apply new structural criteria to 105L	Moderate	1,500	Mitigate	300	Low	0	0	700
Redesign, per SGS inputs	Low	500	Accept	0	Low	0	0	500
Redesign for changes, per DOE/NRC interface	Moderate	200	Mitigate	0	Low	0	0	150
Additional utility design features	Moderate	500	Accept	0	Moderate	0	300	500
Delays initiating design, awaiting R&D completion	High	5,360	Mitigate	0	Moderate	0	240	720
Delays, redesigning for classified process control system	Low	60	Avoid	0	---	N/A	N/A	N/A
Add features to meet IAEA	Moderate	500	Mitigate	0	Low	0	0	50
Uncertainty in obtaining contingency funds	Moderate	2,000	Avoid	0	---	N/A	N/A	N/A
Disposal of bundling tubes	Moderate	100	Avoid	75	---	N/A	N/A	N/A
Decontamination of final-product canister	Moderate	500	Avoid	341	---	N/A	N/A	N/A
Storage location for depleted uranium	Moderate	100	Avoid	75	---	N/A	N/A	N/A
Availability of emergency generator and fuel tank	Moderate	40	Avoid	0	---	N/A	N/A	N/A
Redesign for necessary structural supports	Moderate	300	Avoid	225	---	N/A	N/A	N/A
Arithmetic Sums:		**48,630**		**1,989**		**0**	**3,295**	**21,170**

T&PRA Contingency (at 80% Confidence Level) using Monte Carlo simulation = $7.371K

Figure 8-8. Impact of Risk Handling on Project Cost

Cost Analysis Methods

There are a number of methods available for determining the impact of risk on a project. One method is to assign a standard, flat percent contingency to the cost estimate, as determined by the cost estimator and project manager. This method can be termed the *"flat rate contingency"* method and is generally useful for activities where estimating uncertainty is know, based on historical data and experience. This flat rate calculation is applied individually to each function or activity such as engineering or construction instead of applying it to the overall project cost. The sum of the individual components become project risk.

The second contingency estimation method for projects with a number of moderate or high risks is termed the *"Monte Carlo simulation"* method. This is performed by defining the cost of each activity in terms of a cost profile, namely a cost probability distribution. Once the profiles are known, they can be statistically combined using the Monte Carlo simulation method.

The result of the simulation will be a project risk cost profile versus the probability of project success. This method is extensively used in the insurance industry to determine insurance rates based on mortality data. There are software tools such as Crystal Ball®, Risk for Microsoft Project®, or Primavera® Monte Carlo that can be used to do similar modeling. A similar cost impact analysis approach could be used to determine the impact of risk on schedule. This process is summarized below.

Application of the Monte Carlo Method

The Monte Carlo method uses individual cost vs. probability distributions for each of the residual risks to statistically generate the overall cost vs. probability profile. The simulation software also generates a sensitivity chart showing the impact of the various risk-based cost elements on the overall distribution.

As noted above, the process begins with preparation of an input probability distribution for each of the residual risks. In general, for each residual risk there is a range of costs with the best case and worst case estimates. One of the distributions commonly used for cost profiles is the triangular distribution shown in Figure 8-9. Other distributions, such as normal, exponential, or beta, could be used based on the available data and user experience/judgement. Figure 8-10 provides examples of some of these additional distribution functions that are available in Crystal Ball®.

For a triangular distribution, however, one needs only three data points for each residual risk element, namely, the most likely or anticipated cost, the best case cost, and the worst case cost. The most likely value falls between the best and the worst case values, forming the triangular-shaped distribution, which shows that the values near the minimum and the maximum are less likely to occur than those near the most likely value. The various risk elements with their residual cost versus probability profiles are provided as input to the model.

Assume a triangular cost distribution for each residual risk, where:

L = low or best case estimate
M= most likely case estimate
H = high or worst case estimate

Note: Other distributions such as beta, exponential, and logarithmic can also be used for residual risk cost estimates. The use of these other distributions to better fit the expected cost risk probability distributions depends upon the experience of the risk facilitator.

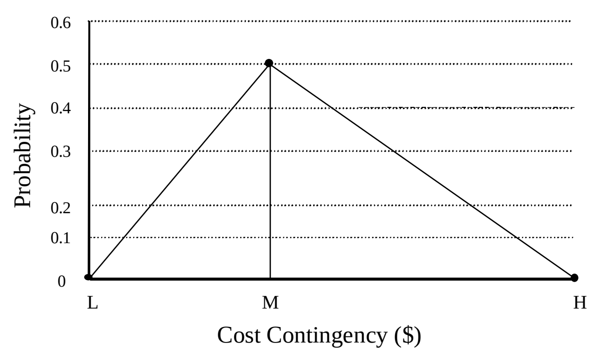


Figure 8-9. Triangular Residual Risk Cost Distribution

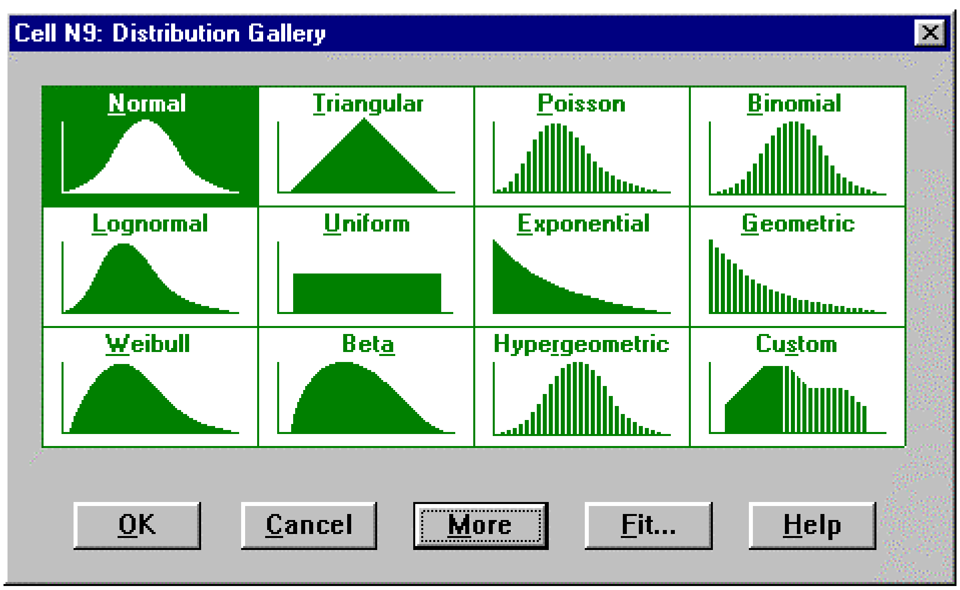


Figure 8-10. Other Available Probability Distributions

Calculation of the Total Residual Risk Cost Contingency Distribution

Once this data is obtained, the individual residual risk costs can be statistically combined as shown in Figure 8-11 using Monte Carlo simulation to obtain the overall project cost vs. probability profile. A total cost distribution is generated using the random sampling methodology or Monte Carlo method. This is usually done using a Monte Carlo software tool available from commercial vendors. Crystal Ball® software was used to generate the total cost distribution in this model (see Figure 8.12).

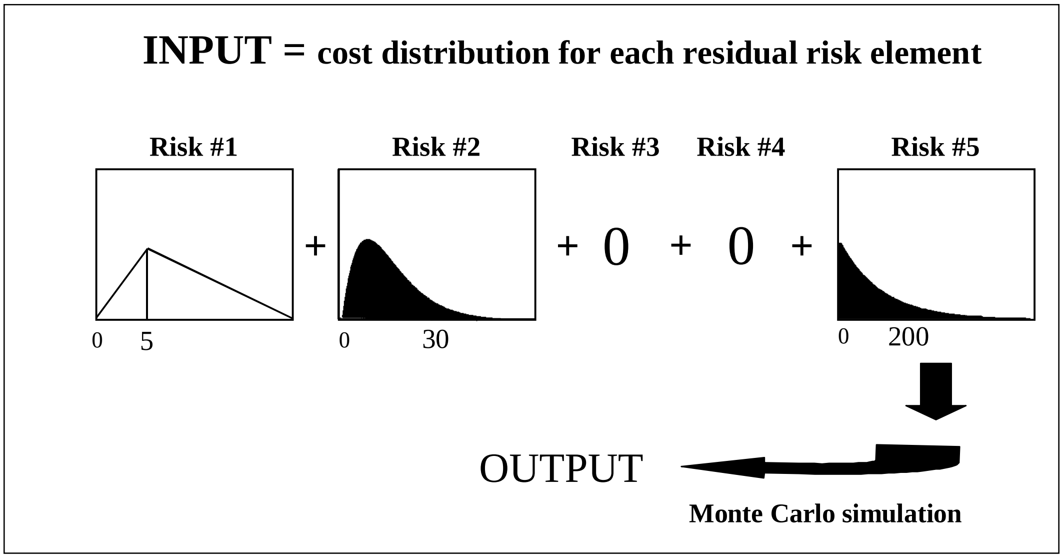


Figure 8-11. Probabilistic Sum of Residual Risk Costs (Monte Carlo simulation)

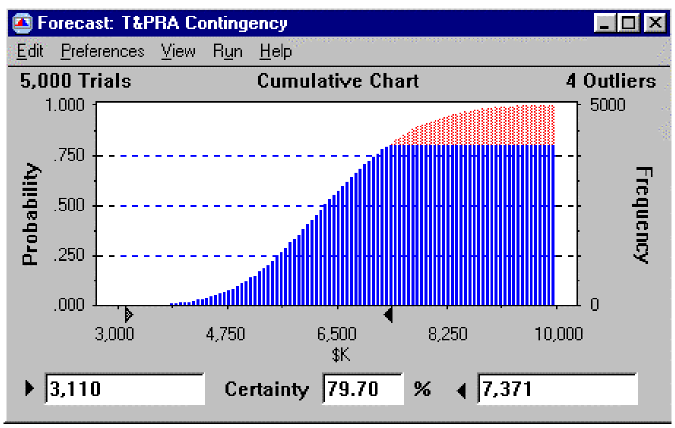


Figure 8-12. T&PRA Contingency Profile

Schedule Contingency

The residual risk impact on schedule has at least three effects, as follows:

1. It potentially delays the completion of the specific task element(s).

2. As a result of the slip, the task element(s) that precede or follow the affected element will also be impacted; this can result in a cost impact.

3. Additional project cost (in the form of such things as overtime differential pay, etc.) may be incurred for delays in schedule completion.

For example, resources may have been staged to perform various project activities. If one activity is delayed, there is a schedule impact. In addition, the resources to perform the follow-on activities will have to be idled or allocated to other tasks or activities which can result in demobilization and remobilization of manpower resources. This results in a cost impact. The term “hotel load” cost is used for the task of “maintaining a core work group in a standby mode” when task element(s) are delayed.

The method to determine the impact on the schedule and establish a schedule contingency is similar to the contingency analysis and uses the Monte Carlo method. The schedule impact is determined for each residual risk element in the form of “best case,” “most likely case,” and “worst case” estimates. Using project scheduling software such as Primavera® Monte Carlo, the schedule risk profile can be determined. The schedule contingency can be calculated, based on the amount of risk that one is willing to take.

The “hotel load” costs associated with the schedule contingency are also determined for each residual risk element and the “hotel load cost” contingency is calculated using Monte Carlo method. This is termed “cost of schedule contingency” and is added to the cost estimate contingency.

8.2.6 Risk Reporting and Tracking

Risk reporting is the documentation of the risk identification, quantification, handling, and impact determination activities for a project in a risk analysis report. This report normally becomes a reference in the project’s overall risk management plan for use in future risk analysis activities.

Risk tracking is the active monitoring of action items developed from risk handling strategies and the identification of a need to evaluate new risks and /or reevaluate changes in previously identified risks. Risk tracking can typically monitor the following types of information:

- Accomplishment of detailed scheduled milestones, specifically as they apply to risk handling elements
- Cost data including both monthly and periodically generated status information
- Research and development studies, engineering studies, and science and technology roadmaps
- Test results, especially for risky program elements
- Technology transition plans (formalizing an agreement between the technology developer and technology user)
- Project action item list

Typical useful management indicators, depending upon the project, can include

- monthly and periodic status reports.
- technical performance measures.
- character and scope of design review action items.

Because the types of information and indicators being monitored are so diverse, appropriate tracking tools will vary widely among projects. A tracking system and tracking tools should be defined that are commensurate with the size and complexity of the project. The selection and definition of a tracking system to be used in a project is normally defined in the project's risk management plan.

Unfavorable trends from risk tracking indicate either that risks were not fully or properly defined, or that handling strategies were not adequate. In such cases, the risk analysis must be re-evaluated.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

NOTE: This Attachment has its own appendices, tables and figures

RISK MANAGEMENT PLAN
for
SPENT NUCLEAR FUEL
TREATMENT AND STORAGE FACILITY (U)

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Prepared by

______________________________	__________
Systems Engineering	Date
______________________________	__________
Systems Engineering	Date

Approvals

______________________________	__________
SFSD Design Authority Manager	Date
______________________________	__________
SFSD Program Manager	Date
______________________________	__________
Project Engineering Manager	Date
______________________________	__________
Project Manager	Date

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

TABLE OF CONTENTS

Section

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

1.0 INTRODUCTION

The Risk Management Plan (RMP) for the Spent Nuclear Fuel-Treatment and Storage Facility (SNF-TSF) Project S-7703 defines the scope and process for identification, evaluation of impact and management of risks applicable to the project. Risk Management will include assessable risks that could potentially jeopardize the successful completion of the project and will also address risks that potentially jeopardize facility operation and final facility decommissioning as related to or caused by this project.

This plan includes the work that earlier project activities had identified, identifies approaches to handle these issues, and expands risk management to include new risks due to project/design evolution. The risk assessment is based on the entire project scope, both programmatic (nontechnical) and technical project risks.

The objective of this plan is to define the strategy to manage project-related risks throughout the remainder of the project's life cycle, such that there is acceptable, minimal impact on the project's cost and schedule as well as on the conduct of the facility's operational performance.

1.1 PROJECT RISK MANAGEMENT HISTORY

A Risk Assessment Program Plan[1] was issued in November 1997 in preparation for the SNF alternative technology decision analysis. A technology risk assessment[2] was conducted as a first step in the decision analysis to determine if either, or both, of the technologies being considered posed significant risks that would make them unsuitable for further development. The risk assessment concluded that both technologies (Melt and Dilute and Direct Co-Disposal) were acceptable for further development provided that the mitigation strategies recommended by the team for high and moderate risks were followed and tracked through completion by a project team. Risk mitigation plans and risk handling, tracking, and closure were left for a future plan. The decision analysis that followed identified a preference for the Melt and Dilute technology, which is now the basis of the TSF project.

This risk management plan and subsequent risk assessment will be based on up-to-date project cost, schedule, and scope information. The assessment will include consideration of the moderate and high risks identified in the previous risk assessment for the Melt and Dilute technology.

1.2 PURPOSE AND SCOPE SUMMARY

The purpose of this RMP is to assure that the SNF-Treatment and Storage Facility project incorporates appropriate, efficient, and cost-effective measures to mitigate unacceptable project-related risks.

This plan establishes the concept and defines the process for risk management for the project. It describes the roles and responsibilities of project personnel in performing the risk management functions, and defines reporting and tracking requirements for risk-related information.

The product of this risk analysis will be a risk analysis report listing the various risks with their classification, mitigation and handling strategies, impact on cost and schedule, and project action items. A typical summary database is shown in table form in Appendix A.

The risk management process will:

- Identify potential sources of risk and the mechanisms forming these risks
- Assess individual risks and their impact on project and facility performance, cost, and schedule
- Evaluate alternative approaches to mitigate high and moderate risks
- Develop action plans to handle (i.e., avoid, reduce, transfer, or accept) individual risks
- Interface risks with other projects/programs

The risk management process specified in this plan was established during project team meetings with risk assessment personnel. The risk analysis process will follow the requirements of WSRC Manual E 11 and E7 for both technical and nontechnical project risks. Risk assessments will be performed in accordance with the Risk Management Guidance Document WSRC-IM-980003 (Reference 4.2) and the instructions in Appendices B and C of this plan. This will be consistent with DOE Order 430.1 and its associated guides. This RMP will remain valid for the life cycle of the project and will be under project configuration control. RMP revisions will require approval that is identical to the initial approval level.

1.3 SCOPE LIMITATIONS

The scope of this RMP will include risks generally originating from several interfacing project areas such as engineering, construction and startup; and also other external infrastructure activities related to utilities, safeguards and security, and interfacing SRS waste generating, processing, and storage facilities, etc., that

[1] Risk Assessment Program Plan (U), Transfer and Storage Services for Aluminum-Based Spent Nuclear Fuel, G-ESR-G-00027 Revision 0, November 1997.

[2] Spent Nuclear Fuel Alternative Technology Risk Assessment (U), Y-TRA-G-00001 Rev. 0, July 16, 1998.

are required for the project. However, risks generated by SRS-external sources will be managed on a case-by-case basis at the direction of the Project Manager.

The risk management process will identify, analyze, and handle risks that potentially affect the facility structures, systems, and components affected by the project. It will establish a risk hierarchy that traces each high and moderate risk to the appropriate level of design detail and will report status and closeout of high and moderate risks. As documented in the TSF Systems Engineering Management Plan[3], the TSF project risk policy is that high risks will not be accepted and must be reduced to at least moderate risks through implementation of a risk mitigation strategy. If this is not possible, PE&CD, Spent Fuel Storage Division, and DOE Management will be advised. Moderate risks will be considered on a case by case basis for potential mitigation actions, and low risks will not be mitigated or tracked, but will be retained in the risk assessment report for future reference only and closed out without further handling.

The plan will track, as a potential risk to the project's cost and schedule, the successful mitigation of hazards to the environment, and safety and health of the public or the worker (i.e., "ESH Risks"). However, in accordance with SRS policies (WSRC 1-01 Management Policy 4. 1, "Environmental Protection" and Policy 4.5, "Nuclear Safety") regarding risk management for projects and facilities, this RMP excludes the detailed management and handling of these ESH Risks. Other documents, such as WSRC Manual E7, Conduct of Engineering, specify procedures for assuring that these ESH risk are within SRS limits and meet ALARA requirements.

[3] Systems Engineering Management Plan for SNF Treatment and Storage Facility (U), Y-PMP-L-00001 Rev. 0, September 21, 1998.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

2.0 PROJECT BACKGROUND & RISK MANAGEMENT

2.1 PROJECT BACKGROUND

The Department of Energy (DOE) Environmental Management Program (EM) has the responsibility for the safe, effective, and efficient storage of the current and future inventory of DOE-owned spent nuclear fuel (SNF). This SNF, including the returned foreign research reactor and domestic research reactor SNF, will be prepared for disposal and stored in a road-ready condition awaiting placement in a permanent geologic repository. Per the DOE SNF Programmatic Environmental Impact Statement Record of Decision, SRS is designated to manage the aluminum-clad SNF inventory for the DOE complex, as well as projected receipts for the next 30 to 40 years. The TSF project will perform a major role in the management of this SNF.

Recent evaluations have confirmed the technical feasibility and potential cost savings for the reuse of the 105-L facility for housing the TSF project. The project consists of direct de-inventory of the existing wet basins to repository-ready storage via transfer and treatment provisions installed in the 105-L Reactor Building. Summary features of the project are:

- Continued receipt at L-Area Disassembly Basin of DOE-owned aluminum-clad SNF from domestic and foreign research reactors using existing equipment. Existing cask decontamination equipment in the stack area will also be used.
- Preparation of the SNF for disposal at a national repository using the melt and dilute treatment technology, with new furnaces and associated support equipment, including an off-gas system, installed in the 105-L Process Room. SNF will be transferred to the Process Room from the L-Area Disassembly Basin via the D&E canal using a modified D&E conveyor.
- Load treated SNIF into a canister/transfer cask, and perform scaling and leak testing operations using new transfer cell and canister preparation equipment installed in the existing Crane Maintenance Area.
- Load the transfer cask onto a special transporter in the Stack Area using the existing crane. Transfer the canister of treated SNIF to dry interim storage, consisting of a modular storage system installed outside the 105-L Building.
- Load canisters of treated SNF into transportation casks for transport off the SRS for storage or disposal.

In general, the project will make use of existing structures, systems, or components (SSCs) where possible, and add new SSCs where necessary.

2.2 PROJECT ASSUMPTIONS

This Risk Management Plan will take a broad view of the Treatment and Storage Facility project to address specific risks that require assessment, mitigation, and tracking. Risk assessment will be an ongoing process throughout the project life cycle. This initial assessment will be focused on the establishment of a valid project baseline prior to project validation. In addition, the following assumptions will serve to guide/bound the risk assessment:

a) It is assumed that the particulate type SNF (as identified in Appendix B of the Technical Performance Requirements for Proposed Treatment and Storage Facility for Spent Nuclear Fuel, WSRC-TR-98-00218, Rev. 0, July 28, 1998) can be treated by the melt and dilute process at some time in the future with relatively minor modifications (Reference 4.3). Because of uncertainties in the receipt condition, form, packaging, and the length of time until receipt, the TSF project scope does not include functions specific to particulate material at this time.

b) It is assumed that the transfer shipments between Building 105-L and the Road-Ready Storage area are not required to meet NRC transportation requirements.

c) It is assumed that L-Basin will be available for the life of the TSF for continued receipts, wet storage, conditioning, and characterization of SNF.

d) It is assumed that the L-Area Disassembly Basin will have the capability to receive and unload all SNF shipments to SRS during TSF operations.

e) It is assumed that changes to the Mined Geologic Disposal System Draft Disposability Interface Specification (1300000000-01717-4600-00108, Rev. 0, February 1998) will not cause major changes to the TSF.

f) It is assumed that the Record of Decision for the SRS SNF Management EIS will select the melt and dilute treatment technology.

g) It is assumed that the TSF will not be NRC licensed.

h) It is assumed that the treated SNF to be shipped to the MGDS becomes the responsibility of DOE-RW when the loaded transport cask is on the railcar or trailer. From that point on, DOE-RW is responsible for performing the shipping function and what follows.

i) It is assumed that the loaded road-ready canisters will not require opening for any sort of inspection or repackaging, as part of TSF activities.

2.3 STRUCTURE FOR RISK ANALYSIS

The functional areas/systems listed below are in alignment with the TSF FDD and will be used as the assessable elements for the risk assessment:

0 TSF Program
1 SNF Pretreatment
2 Furnace
3 Off-gas
4 Secondary Waste
5 HVAC
6 Remote Handling
7 Characterization
8 Packaging
9 Controls
10 Material Handling
11 Fire Protection
12 Power (normal and emergency)
13 Safeguards and Security
14 Structures
15 Road-Ready Storage
16 Balance of Plant.*

*Balance of Plant includes Air, Inert Gas, Plant Communications, Radiation Monitoring and Protection, Road and Rail, Service Water, and Storm Sewer.

2.4 PROJECT RISK MANAGEMENT TEAM

The project risk management team will consist of the core project team with additional subject matter experts participating as appropriate in the risk identification and analysis. The core team is comprised of:

- Project Manager
- Project Engineering Manager
- Program Manager
- Design Authority Engineering Manager
- Operations Manager
- SRTC Melt and Dilute Development Task Lead
- Safety (WSMS)
- Systems Engineering Lead.

2.5 RESPONSIBILITIES FOR RISK MANAGEMENT

The Project Manager has overall responsibility for project risk management and the implementation of this risk management plan. The activities required to implement the following responsibilities may be delegated; however, the responsibility remains with the identified function.

<u>Project Manager;</u>

- Is responsible for the development and approval of the Risk Management Plan (RMP)
- Will provide budget for RMP implementation activities
- Will actively participate in the project's conduct of risk management, particularly in remedial actions, such as:
  (a) mitigation of programmatic risks, when the project's scope, budget, or schedule are impacted
  (b) mitigation of interfacing risks when other organizations (outside SRS) are involved
- Or designee will chair the risk assessment meetings
- Will assemble and lead the Project Team in the risk analyses
- Will assure the risk analysis results are documented and risk mitigation plans are brought to closure
- Will schedule periodic reviews of the risk summary report and the status of the associated handling actions, delegate risk coordination to the Systems Engineering Lead.

<u>Project Engineering Manager</u>

- Will actively participate in the project's conduct of risk management, particularly in remedial actions, such as:
  (a) technical risks, when the project's scope, budget, or schedule are impacted
  (b) interfacing risks when interfaces to other SRS organizations are involved
- Will identify the need for technical risk analyses
- Will approve the risk management plan.

Design Authority Engineering Manager

- Will actively participate in the project's risk management activities that relate to design and engineering activities and their interfaces.
- Will approve the risk management plan.

Program Manager

- Will coordinate and integrate the other project activities (such as operations, external issues) with the programmatic risk management activities.
- Will approve the risk management plan.

Systems Engineering Lead

- Is responsible for the maintenance of the RMP
- or designee will schedule risk assessments, propose meeting agenda, and approve meeting minutes
- Will designate a Risk Management Coordinator
- Will prepare and periodically present to the Project Manager and Project Engineering Manager a summary status of risk mitigation activities and status of RMP implementation.

Risk Management Coordinator

- Will facilitate risk assessment meetings
- Will manage the identification, the assessment, and rating of risks
- Will prepare a set of identified risks and risk handling strategies.

Project Team Members

- Will perform risk screening to identify risks
- Will assess and grade identified risks
- Will develop risk mitigation strategies.

3.0 RISK MANAGEMENT PROCESS

3.1 RISK MANAGEMENT ACTIVITIES

The risk management process will follow the requirements of WSRC Manual E11 and E7 for both technical and noNtechnical project risks. Risk assessments will be performed in accordance with the instructions of Appendices B and C of this plan and Risk Management Guidance Document WSRC-IM-980003 (Reference 4.2). Each project element, as identified in Section 2.3, will be assessed. The risk areas suggested by the Risk Screening Form included in Appendix D will be used to initiate identification of risks.

Evaluations of the status and mitigation progress of identified risks, any additional identification of new potential risks, and the closure of acceptable risks will be performed at key points in the project cycle, including:

a) Prior to completion of the TPC Estimate for Validation of the Design Project,
b) Prior to Project Critical Decisions
c) At selected points during detailed design and construction as identified in the Project Team Execution Plan.

Additional risk assessments may be added in support of the procurement and construction schedules, as appropriate. The Project Manager will schedule and initiate risk screening as needed to identify new potential risks.

The project risk management process contains the following major elements:

1) Risk Management Planning
2) Risk Identification
3) Risk Analysis
4) Risk Mitigation
5) Risk Tracking, Reporting, and Closure.

Figure 3-1 depicts these major elements and their sub-activities.

3.1.1 Risk Management Planning

The planning activity will identify the assumptions and the level of risk assessment. The SNF-TSF project risk team will review all the risk elements of the project in detail including both technical and programmatic activities. This is documented in this Risk Management Plan.

3.1.2 Risk Identification

The assessable elements for the project are shown in Section 2.3. This is based on the individual systems and structures that comprise the project with their associated functions. The analysis will consider the risks related to various elements.

3.1.3 Risk Analysis

The risk analysis process will classify the risks into high, moderate, or low based on the charts shown in Appendix B. The criteria or definitions for the probability and the consequences of the risk being realized are also shown in Appendix B.

The analyses will be documented in the Risk Analysis and Identification Form, shown in Table 5-1 of Appendix A.

3.1.4 Risk Mitigation and Handling

The handling of risks is the process that will either ensure that a risk is acceptable to the project or make an unacceptable risk acceptable. This effort will commence after the risk assessments and grading have been completed. The first activity is the establishment of priorities and the level of justifiable effort for the handling of the individual risks.

In general, the following four strategies are acceptable alternative means to mitigate risks. They are:

1. Risk reduction,
2. Risk avoidance,
3. Risk transfer, or
4. Risk acceptance.

Each completed risk analysis will contain a recommended risk-handling process, which will form the basis for the risk-handling plan. The objective of the risk handling plan is a graded approach establishing a risk handling priority and a level of justifiable effort for risk handling, with the basis being the risk level as determined by the frequency of risk occurrence and the severity of risk consequences. Risk priority and the availability of budgets and personnel resources determine the execution sequence of each risk mitigation.

3.1.5 Risk Tracking, Reporting, and Closure

Handling strategies for all high risks will result in a schedule activity. Standard project implementation of these schedule activities will be the primary tool for tracking and reporting the status of all high risks. It will record the progress of risk mitigation by listing up-to-date information on risk status and closure.

- Risk identification
  - -description of risk
  - -source of risk
- Risk assessment data
  - -risk level
- Risk mitigation
  - -risk mitigation strategies
  - -impacted SSC
  - -risk resolution.

Moderate risks will be recorded in the Project Action Item list, either individually or as a distinct collection of multiple risks.

Periodically scheduled meetings will be the platform for identifying and concurring with newly identified risks to be added to the database for risk processing. The meeting frequency, attendance, and conduct will be the responsibility of the Project Manager or designee.

Risk status meetings will be used to review the progress of all top-level risks and any other risks of important concern, and resolve apparent risk-handling problems. The objective of these status meetings is to focus on the progress of high risks and to make efficient use of project and other staff expertise. The conduct of these status meeting will be the responsibility of the Project Manager.

An assessment of the status of applicable identified project risks will be performed by the project team during conduct of subcontracts for project engineering and design (E&D), and the proper management of risks in accordance with this plan will be imposed on E&D subcontractors.

The risk management database will contain relevant data on identified programmatic and technical project risks and will reflect the current status of risks. It will maintain files on risks that have been closed.

The format of the risk-handling strategies will be such that they can interface with other already existing project databases (e.g., schedule activities list) to allow for efficient data generation and transfer.

3.1.6 Risk Analysis Report

The process of risk handling will be documented in a Risk Analysis Report. This report will (a) document the results of completed risk identification activities, (b) contain the detailed risk assessments, and (c) provide the recommended mitigation of individual risks. This report will be initially issued for the preliminary design phase under the Project Engineering Manager's approval and will be periodically updated if new risks are identified or existing risks are deleted.

3.1.7 Trend/BCP

Mitigation actions will be evaluated as potential trends per Project S-7703 guidelines. Changes to the mitigation actions for high risks will require the approval of a Baseline Change Proposal (BCP). Changes to the risk value resulting from the completion of planned actions do not require approval of a BCP.

4.0 REFERENCES

4.1 WSRC Manual E11, Conduct of Project Management and Controls, Procedure 2.62, Revision 1, February 1, 1997, Project Risk Analysis.

4.2 Systems Engineering Methodology Guidance Manual, WSRC-IM-98-00033, Appendix B Risk Management, Revision 0, September 25, 1998.

4.3 Bases for Functional Performance Requirements for a Spent Nuclear Fuel Treatment and Storage Facility, WSRC-TR-98-00228, July 1998.

4.4 WSRC Manual E7, Conduct of Engineering and Technical Support, Procedure 2.16, Revision 0, July 1, 1995, Technical Risk Analysis.

5.0 APPENDICES

5.1 Appendix A - Typical Risk Management Data for SNF Treatment and Storage Facility Project

5.2 Appendix B - Instructions for Template for Individual Risk Assessments for SNF-Treatment and Storage Facility

5.3 Appendix C - Guidelines for Conduct of Risk Management Activities for SNF-Treatment Storage Facility Project

5.4 Appendix D - Risk Screening Form

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

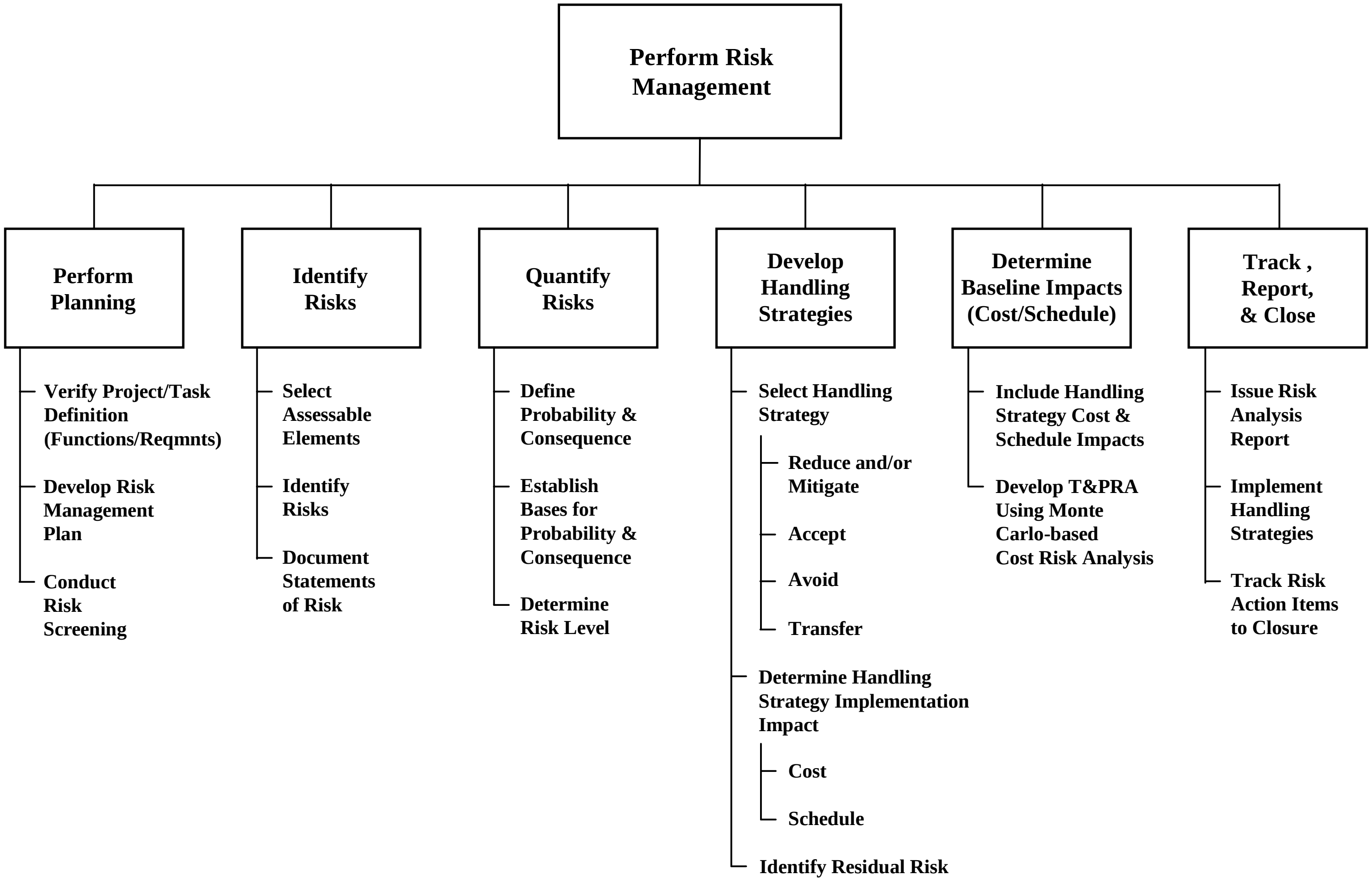


Figure 3-1 Function Tree for Risk Management Process

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

5.1 Appendix A - Typical Risk Management Data for SNF-Treatment and Storage Facility Project

RISK NUMBER	RISK LEVEL	RISK IDENTIFICATION (What is it?)	RESPONSIBILITIES (Who handles the risk?)	RISK HANDLING/TRACKING (How is it mitigated/resolved?)	RISK CLOSURE (What solves it, what is remaining on risk?)
Numbering consistent with the schedule activities numbering system, with cross reference to risk assessment number	High	Description of hazard Source of risk (project-internal/external) Impacted/interfacing equipment	Who (organization/individual) Schedule (any critical restraints?)	Risk handling document No. Risk resolution/mitigation	Risk closure document & date
Numbering consistent with the project action item list numbering system, with cross reference to risk assessment number	Moderate	General description of issue or action item caused by risk(s) Impacted equipment	Who (organization/individual) Schedule (any critical restraints?)	Risk handling document No., if applicable Risk resolution/mitigation	Risk closure date
Risk assessment number	Low	Listing of all low risks (without further mitigation)	NA	NA	NA

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

5.2 Appendix B

Instructions for Template for Individual Risk Assessments for SNF-Treatment and Storage Facility

Purpose

Table 5-1 is a template to be used for the SNF-Treatment and Storage Facility risk assessments. It is similar to the form that has been used for previous risk assessments. It contains the risk assessment parameters for each risk and, when completed, provides the necessary information for any further handling of the risk.

Guidance for Completion of the Template

Date: This date is the date of the specific risk assessment of the project/project element. This date will be specified with the assessment and will change only when the assessment of the individual risk changes.

Risk Number: This is a sequential number assigned to a risk after it was determined that a potential risk requires further assessment. Each risk will maintain its assigned number.

Location Description: The specific area/building in which the risk is located shall be specified here. (See listing of applicable buildings for proper identification or use "Project/Programmatic" for project-level risks).

Statement of Risk: A brief and precise statement of why the risk is important. The statement shall be formulated to clearly indicate a risk by stating "What we are concerned about." The statement should be limited to two lines of text to allow meaningful entry into the risk management database.

Probability: The probability that the identified risk will materialize shall be judged and scored under the following guidelines:

Probability of Occurrence	Criteria
0, 0.1 (Very Unlikely)	Will not likely occur anytime in the life cycle of the project; or estimated occurrence interval > 10,000 years.
0.2, 0.3, 0.4 (Unlikely)	Will not likely occur in the life cycle of the project; or 10,000 years > estimated occurrence interval > 100 years.
0.5, 0.6, 0.7 (Likely)	Will likely occur sometime during the life cycle of the project; or 100 years > estimated occurrence interval > 10 years.
0.8, 0.9, >0.9 (Very Likely)	Will likely occur sometime during the life cycle of the project; or Estimated occurrence interval < 10 years.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Consequences: The severity of the consequences, should the risk occur, shall be described, judged, and scored under the following guidelines:

Consequence of Occurrence	Criteria
≤ 0.3 (Negligible)	Small, acceptable, reduction in project technical performance. Minor threat to facility mission, environment, or people; possibly requires minor facility operations or maintenance changes without redesign, routine cleanup, or first aid. Cost estimates (TPC) increase by up to $500K. Minor slip in schedule, measurable in weeks, with some potential adjustment in milestones required.
0.4, 0.5 (Marginal)	Some reduction in project technical performance. Moderate threat to facility mission, environment or people; possibly requires minor facility redesign or repair; moderate environmental remediation or causes minor injury requiring medical intervention. Cost estimates (TPC) increase by >$500K and up to $2.5M. Moderate slip in schedule, between 1 and 6 months, and adjustment to milestones.
0.6, 0.7 (Significant)	Significant degradation in project technical performance. Significant threat to facility mission, environment, or people; requires some facility redesign or repair; significant environmental remediation or causes injury requiring medical treatment. Cost estimates (TPC) increase by >$2.5M and up to $12.5M. Significant slip in development schedule, between 6 and 12 months, and modification to milestones or affect on facility mission.
0.8, 0.9 (Critical)	Technical goals of project cannot be achieved. Serious threat to facility mission, environment, or people; possibly completing only portions of the mission; or requiring major facility redesign or rebuilding; extensive environmental remediation or intensive medical care for life-threatening injury. Cost estimates (TPC) increase by >$12.5M and up to $ 25M. Excessive schedule slip, exceeding 1 year, affecting overall mission of the facility or site.
> 0.9 (Crisis)	Project cannot be completed. Catastrophic threat to facility mission, environment, or people; possibly causing loss of mission; long-term environmental abandonment and death. Cost estimates (TPC) increase by >$25M. Excessive schedule slip unacceptably, affecting overall mission of facility/site/DOE objectives, etc.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Risk Level: The level of each risk is a function of the probability of the risk to materialize, times the severity of the consequence when the risk occurs (i.e., Risk Factor = Probability x Consequence). Table 5-1 depicts a relationship that will allow the determination of each risk level, once the probability and consequence of a particular risk are known.

The risk levels are identified in the Risk Analysis Report, including risks that are outside project control, that reflect risks which will be managed through interface control with DOE and other organizations, and by the Project Change Control system. These risks have no risk level assigned and are identified by "O/C" in the Risk Analysis Report.

Table 5-1 Risk Level Determination

Risk Factor	Risk Level
Less than. 0.1	Low
Between 0.1 and 0.5, inclusive	Moderate
Greater than 0.5	High

Consideration of First-of-a-Kind Risks

Most innovative projects carry an additional risk potential for failure when they are based on –"First-of-a-Kind" (FOAK) technology or FOAK structures, systems, or components. The project may or may not contain FOAK risks, and the risk analyses will be used to determine any FOAK risks. Although certain processes are not FOAK by themselves, they may very well become FOAKs when considered working together. e.g., robotics in highly radioactive environments. Other FOAK candidates are processes/components with large scale factors, i.e., existing and proven equipment that has been scaled up by a factor of, say, more than five.

Identified FOAK risks will generally be assigned a frequency range/numerical value in the "Very Likely" area and a consequence severity consistent with "Critical" or "Crisis" unless lesser ratings can be substantiated.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Table 5-1 Template for Project Risk Assessments

Risk Assessment Form

Risk Identification No.: *00-00001*

Assessed Element:

Risk Title:

KASE #:

Risk Category (Optional):

Risk Type:

Date:

Responsibility:

A. Statement of Risk: *(State Event and Risk)*

B. Probability: *(State the probability and basis that the risk will come true without credit for RHS)* P= ______

○ Very Unlikely(VU) ($P \leq 0.1$) ○ Unlikely(U) ($.2 \leq P \leq 0.4$) ○ Likely(L) ($.5 \leq P \leq 0.7$) ○ Very Likely(VL) ($.8 \leq P \leq 1.0$)

C. Consequence: *(State the consequences and quantify basis if that risk comes true without credit for RHS)* C= ______

Worst Case Cost Impact: ______ Worst Case Schedule Impact: ______

○ Negligible(N) ($C \leq 0.1$) ○ Marginal(M) ($.2 \leq C \leq 0.4$) ○ Significant(S) ($.5 \leq C \leq 0.7$) ○ Critical(C) ($.8 \leq C \leq 0.9$) ○ Crisis(Cr) ($C > 0.9$)

D. Risk Level: ○ Low(L) ○ Moderate(M) ○ High(H) Probability x Consequence = Risk Factor (optional): ______

E. Risk Handling Strategies:

Risk Handling Approach	Risk Handling Strategy (RHS) Description and Bases	Reduced			Implementation		Tracking# (Optional)
		Prob.	Cons.	Risk	Cost	Schedule	

F. Residual Risk Impact: Cost Consequence: ______ ______ ______

Schedule Consequence: ______ ______ ______

Best / Most Likely / Worst

G. Description of Residual Risk:

H. Schedule to Cost Conversion Factor: $ ______ per unit ______

I. Affected WBS:

J. Additional Comments (optional):

Unclassified ONLY

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

5.3 Appendix C - Guidelines for Conduct of Risk Management Activities for SNF-Treatment and Storage Facility Project

Section 3.1 describes the risk management activities for the project. Section 2.3 lists the elements to be assessed for the project.

(a) Planning of Risk Management:

As specified by this document.

(b) Identification of Risks:

Potential risks are identified by project team members from various disciplines in meeting sessions initiated by the Project Manager, with subject matter experts participating at the Project Manager's request. The basis for the identified risks will be established, and each risk will receive a judgmental rating (high, moderate, low) at that time.

(c) Risk Analyses:

The identified risks will be analyzed by project subject matter experts for the parameters listed in Table 5-1 (Template). The analyses will be performed under the guidance of Manual El1, Procedure 2.62, for technical and programmatic project risks. Project risk assessments will use Risk Level Table 5-2 for assigning the applicable risk level of "High," "Moderate," or "Low." Additional instructions are provided in Appendix B.

(d) Handling of Risks:

Risk Handling is identification of a strategy for ensuring that risks are acceptable to the project. In general, the following four strategies are acceptable alternative means to handle risks: (1) risk mitigation, (2) risk avoidance, (3) risk transfer, or (4) risk acceptance.

For the SNF-Treatment and Storage Facility, only high risks and moderate risks will be considered for mitigation. Low Risks will be recorded and retained in the risk analysis report. Mitigation activities will be evaluated as possible "Trends" per project guidelines. Changes to the mitigation actions for high-level risks, once incorporated into the project, require an approved BCP.

Risk mitigation is the process that will make an unacceptable risk acceptable. This effort will commence after the risk analysis and grading processes are completed. The first activity is the establishment of priorities and the level of justifiable effort for the handling of the individual risks.

<u>To (1): Mitigate the Risk:</u>

Each completed risk analysis will contain mitigation strategies that recommend risk handling that will form the base for a risk-handling plan. The objective of the risk-handling plan is a graded approach by the establishment of a risk handling priority and the level of justifiable effort for risk handling, with the basis being the risk level. Risk priority and the availability of budgets and personnel resources determine the execution sequence of each risk.

A risk can be reduced in its frequency of occurrence or its severity of consequences by engineering studies of alternative technologies or design concepts. However, before an alternative can be chosen, a careful review of the potential for new risks associated with this alternative has to be conducted as part of the risk mitigation effort. Sometimes, new risks can appear in interfaces with related structures, systems, or components.

Each completed risk analysis will contain a recommended course of action prepared by the risk-handling analyst and can form the base for the risk-handling plan. The objective of the risk-handling plan is a graded approach by the establishment of a risk-handling priority and the level of justifiable effort for risk handling, with the basis being the risk grade (risk probability and severity of risk consequences). Risk priority and the availability of budgets and personnel resources determine the execution sequence of each risk mitigation.

<u>To (2) Avoid the Risk:</u>

Risk avoidance requires a clear understanding of the root cause of the risk. Again, changes in technology or design concepts will result in risk reduction or risk avoidance, when the root cause is clearly apparent. The risk-handling plan will specify any risk avoidance efforts.

<u>To (3) Transfer the Risk:</u>

Risk transfer is an action taken when an identified risk can be assigned to another party. Occasionally this strategy is acceptable when a project scope with identified risks can be transferred to another project, especially when this same risk can be more easily handled within the receiving project. Rarely, but on occasion, a risk can be transferred to an outside organization, such as a vendor. This in itself is a risky strategy in that the vendor can go out of business or fail to meet the agreed requirements, leaving the project with the same initial problem. In any case, the individual or organization receiving the risk must accept employment of risk transfer.

<u>To (4) Accept the Risk:</u>

In most cases, risk mitigation is associated with additional cost and schedule impacts, which can force the decision to accept the risk. Additionally, risk mitigation can lead to a partial risk acceptance. In these cases, the project (or the operating facility) can become prepared for the potential for the risk to occur by identifying typical risk trigger points that can be used to activate pre-prepared risk-handling contingencies. The identification of trigger points and the preparation of risk-handling contingencies will be developed as part of the individual risk-handling plan.

(e) Risk Tracking, Reporting, and Closure:

The project schedule activities will be the primary tool for tracking and reporting the status of all high risks. Moderate risks will be entered into the Project Action Item List. The schedule activity database is a permanent document that will contain all relevant data on every identified programmatic and technical high project risk, and will reflect the current status of each risk. It will permanently retain essential records on risks that have been closed. The database will be a controlled document under the supervision of the Project Manager.

Appendix A is an example of a typical format developed with objectives of having the capabilities to enter data, and to search, query, sort, and display any necessary risk information to a level of detail commensurate with the level of risk. In addition, the schedule activities should communicate with other project databases, such as project and task scheduling and commitment tracking databases as applicable to the project.

Other risk management activities for risk tracking and reporting include periodically scheduled meetings as the platform to concur on newly identified risks to be added to the risk database for risk processing. Risk status meetings will be used to review the progress of all top-level risks and any other risks of important concern, and resolve apparent risk-handling problems. Particular attention will be directed to risks that affect facility mission or DOE commitments.

The schedule activities and Project Action Item List will be used to document closed-out risks.

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

5.4 Appendix D - Risk Screening Form

TECHNICAL CATEGORIES

Design

- Undefined, Incomplete, Unclear Functions or Requirements
- Complex Design Features
- Numerous or Unclear Assumptions or Modification Bases
- Reliability
- Inspectability
- Maintainability
- Safety Class
- Availability
- Errors and Omissions in Design

Regulatory & Environmental

- Environmental Impact Statement Required. (EIS)
- Additional Releases
- Undefined Disposal Methods
- Permitting
- State Inspections
- Order Compliance
- Regulatory Oversight

Technology

- New Technology
- Existing Technology (Modified or New Application)
- Unknown or Unclear Technology

Testing

- Construction
- CTO/Maintenance
- Operability
- Startup (Facility)
- Startup (Subcontract or PE&CD)

Safety

- Criticality Potential
- Fire Watch
- Exposure Contamination Potential
- Authorization Basis Impact
- Hazardous Material Involved
- Emergency Preparedness
- Safeguards & Security
- Confinement Strategies

Interfaces

- Multiple Agencies, Contractors
- Special Work Control Work Authorization Procedures
- Operating SSCs Including Testing
- Multiple Customers
- Co-occupancy
  - Outage Requirements
- Multiple Systems
- Radiological Conditions (Current and Future)
  - Contamination
  - Radiation
- Multiple Projects
- Proximity to Safety Class Systems

PROGRAMMATIC CATEGORIES

ATTACHMENT I – PROJECT RISK MANAGEMENT PLAN EXAMPLE

Programmatic

- Funding uncertainties
  - Stakeholders (CAB, customers, etc)
  - Program Strategies Change
- Fast track/critical need
  - Infrastructure influence
- Schedule deferrals
- Schedule acceleration
- Management acceptance of identified risk w/o mitigation

Procurement

- Procurement Strategy
- First-use Subcontractor/Vendor
- Vendor Support

Construction Strategy

- Turn-over/Start-up Strategy
- Direct Hire/Subcontract
- Construction/Maintenance Testing
- Design Change Package Issues

Resource/Conditions

- Material/Equipment Availability
- Specialty Resources Required
- Existing Utilities Above and Underground
- Support Services Availability
- Geological Conditions
- Temporary Resources (Power, Lights, Water, etc.)
- Resources Not Available
- Construction Complexities
  - Transportation
  - Critical Lifts
  - Population Density
- Escorts
- Personnel Training & Qualifications
- Tools, Equipment Controls & Availability
- Experience with system/component (design, operations, maintenance)
- Work Force Logistics
- OPC Resources
  - Operations Support
  - HP Support
  - Maintenance, Construction, Plant Maintenance
  - Construction Post-Modifications
  - CSWE Support
  - TNX Support
  - Multiple Project/Facility Interface
  - Facility Work Control (Priorities vs. Projects)
  - Lockout Support

Work Conditions Resulting in Unusual Applications of General Site Safety Standards

These topics are part of SRS's standard safety practices and job planning.

- Personnel Injury
  - Heat Stress
  - Exposure to Cold
  - Industrial Hazards
  - Process Hazards
  - Use/Creation of Carcinogens
  - Confined Space Work

  - Air Quality
  - Work Elevation Hazards
- Personnel Protection
  - Access to Medical Supplies/Facilities/Personnel
  - Availability of Protective Equipment
- Vehicular
  - Traffic Patterns
  - Traffic Control
  - Pedestrian Areas
  - Unusual Vehicles
- Explosion Potential
- Ergonomics
  - Work Outside Field of Vision
  - Access Reach
- Weather/Climate Conditions

Other

- Schedule
- Cost
- Errors and Omissions in Estimates
- Project Scope Change
- Security
- Housekeeping

ATTACHMENT II – SAMPLE RISK ASSESSMENT FORM

Risk Assessment Form

Risk Identification No.: *PJT-KASE35-00001*

Assessed Element (Optional): 15 233-H Process

Risk Title: Modification of TCAP Technology

KASE # (Optional): 35

Risk Category (Optional): Technology: Existing Technology : Modified

Risk Type (Optional): PJT-Project Programmatic

Date: 11/13/98

Responsibility (Optional): Design Engineering

A. Statement of Risk: *(State Event and Risk)*
TCAP technology will be modified and may not meet expected performance requirements.
Rework/redesign may be required to address such things as heating/cooling method, scale-up, etc..

B. Probability: *(State the probability and basis that the risk will come true without credit for RHS)* P= 0.90
Numerous changes to existing technology in heating/cooling method. Limited technical expertise in the areas analytical model, PDK aging, start-up control and heat transfer.

○ Very Unlikely(VU) (P ≤ 0.1) ○ Unlikely(U) (.2 ≤ P ≤ 0.4) ○ Likely(L) (.5 ≤ P ≤ 0.7) ● Very Likely(VL) (.8 ≤ P ≤ 1.0)

C. Consequence: *(State the consequences and quantify basis if that risk comes true without credit for RHS)* C= 0.70
Significant performance impact, with associated deviation documentation and operations impact, and/or significant design modifications/rework to improve performance. (Cost and schedule impacts are for the project only.)

Worst Case Cost Impact: $1,000,000 Worst Case Schedule Impact: 6 Mo(s)

○ Negligible(N) (C ≤ 0.1) ○ Marginal(M) (.2 ≤ C ≤ 0.4) ● Significant(S) (.5 ≤ C ≤ 0.7) ○ Critical(C) (.8 ≤ C ≤ 0.9) ○ Crisis(Cr) (C > 0.9)

D. Risk Level: ○ Low(L) ○ Moderate(M) ● High(H) Probability x Consequence = Risk Factor (optional): 0.63

E. Risk Handling Strategies:

Risk Handling Approach	Risk Handling Strategy (RHS) Description and Bases	Reduced Prob.	Reduced Cons.	Reduced Risk	Implementation Cost	Implementation Schedule	Tracking# (Optional)
Reduce and Mitigate	Continue component development work, allowing early identification of design issues.	0.4 U	0.4 M	0.16 M	$300K	0	

F. Residual Risk Impact:

	Best	Most Likely	Worst
Cost Consequence:	0	$200K	$500K
Schedule Consequence:	0 Mo(s)	1 Mo(s)	4 Mo(s)

G. Description of Residual Risk: Design perturbations to preclude performance degradation.

H. Schedule to Cost Conversion Factor: $ 200K per unit Mo(s)

I. Affected WBS: TCAP system; engineering labor

J. Additional Comments (optional):
Implementation cost represents EAC cost increase to include addressing change to heating/cooling method, analytical model, packaging, start-up control, scale-up, inside insulation, and heat transfer.

Unclassified ONLY

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

Attached is the residual risk-based cost contingency calculated for the Spent Nuclear Fuels Treatment and Storage Facility (TSF) Project example used throughout this Appendix. This calculation was performed to support a preconceptual design-only estimate. This information is provided in two sections. Section A is a summary of the results, representing the total estimated T&PRA contingency for the project. This section identifies a total residual risk-based contingency of $7.37 million at the 80% confidence level and would be used by the Cost Estimating organization to prepare the final Cost Estimate Report. Section B provides the details feeding into Section A.

Section A includes:

- A listing of the raw data input, as derived from the risk assessment results and subsequent decisions on incorporation of handling strategies – see Figure III-1.
- Listings of all risks documented in the example risk assessment, identifying those avoided by the project's handling strategies, those included in this risk-based contingency estimate, and those funded in the base cost estimate for this example project. Since the cost estimate for this example project as a design-only scope is not yet complete, no risks were eliminated due to their being covered by the existing cost estimate – see Figure III-1.

Section B includes:

- A sensitivity chart that identifies the relative importance of each assumption (i.e. - risk cost probability distribution) in the creation of a forecast (T&PRA contingency) – see Figure III-2.
- A forecast (T&PRA contingency) based upon the probabilistic sum of the assumptions using Monte Carlo simulation – see Figure III-3.
- Assumptions (risk cost probability distributions) assigned to each of the individual risks – see Figure III-4.

Although the inputs provided to this document would be screened to ensure that they did not duplicate entries into the standard project cost estimate, users are advised that screening does not validate the inputs. Furthermore, since the project cost estimate is not yet complete, no technical risks were eliminated in this example. It is left to Project Management and Cost Estimating to ensure that risks included in this analysis are not included in the traditional cost estimate elements and/or variables.

Both the input values and results of this contingency are subjective estimates of the likelihood and cost associated with realizing potential risks. This example is not intended to predict that any one of these individual risks will occur, or that the contingency cost identified will be required beyond the subjective estimate identified. Further, there are a number of very low-probability risks, with extremely high consequences, should these risks materialize. The contingency calculated here is based on the low-probability event. Covering these risks' high consequences is considered to be beyond the ability of the project.

In support of the information provided here, the risk report generated for this project would document and discuss all risks identified by the risk assessment and the handling strategy planned for each risk.

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

Legend for Figure III-1:
Risk Item/Basis – A brief description of the individual risk.
Before Handling, Risk Level – The level of risk determined during the risk assessment prior to the implementation of any handling strategy. The Risk Level will either be *High*, *Moderate*, or *Low.*
Before Handling, Worst Case Cost – An estimated value of the highest cost expected to occur should the residual risk materialize and without the benefit of any handling strategy implementation. This estimate is generally based on the risk assessment team's experience and judgement.
Handling Strategy **–** The type of handling strategy selected by the assessment team for the risk. The Handling Strategy will either be *Reduce, Mitigate, Avoid, Accept,* or *Transfer*.
Cost to Implement Handling – An estimate of the cost for implementing the selected handling strategy. This implementation cost is added to the baseline cost of the project or activity.
After Handling, Risk Level – The level of risk determined during the risk assessment after the implementation of any handling strategy (i.e., residual risk). The Risk Level will either be *High*, *Moderate,* or *Low.*
After Handling, Residual Risk Cost, Best Case – An estimate of the lowest cost that will be incurred by the project in "recovering from" the residual risk, should the residual risk occur. This value is generally based upon the risk assessment team's experience and judgement but is normally zero.
After Handling, Residual Risk Cost, Most Likely – An estimate of the most probable cost that will be incurred by the project in "recovering from" the residual risk, should the residual risk occur. This value is generally based upon the risk assessment team's experience and judgement.
After Handling, Residual Risk Cost, Worst Case– An estimate of the highest cost that will be incurred by the project in "recovering from" the residual risk, should the residual risk occur. This value is generally based upon the risk assessment team's experience and judgement.
T&PRA Contingency – An estimated value of the amount of contingency that is recommended to adequately protect the project against the identified risks following the implementation of handling strategies.

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

SECTION A – SUMMARY OF RISK-BASED CONTINGENCY COSTS

A	C	D	F	G	H	I	M	N	O
2	TSF Risk-Based Cost Contingency								
3		Before Handling				After Handling			
4	Risk Item / Basis	Risk Level	Worst Case Cost ($K)	Handling Strategy	Cost to Implement Handling	Risk Level	Residual Risk Cost Estimates ($K)		
5							Best Case	Most Likely	Worst Case
6	Redesign to solve problems identified during reviews	Moderate	3,360	Mitigate	75	Low	0	150	500
7	Do analyses/design 105 per external comments	Moderate	390	Avoid	0	---	N/A	N/A	N/A
8	Rework design documents during concept evolution	Moderate	5,720	Mitigate	0	Moderate	0	750	2,500
9	Redesign for add'l equipment for ops/pretreat. interface	Moderate	160	Mitigate	0	Low	0	40	100
10	Design for cintering equipment	High	500	Mitigate	308	Moderate	0	0	200
11	Redo design for SNF resizing	Moderate	200	Accept	0	Moderate	0	50	200
12	Redesign; contamination control in process room	Moderate	5,000	Mitigate	361	Moderate	0	300	3,000
13	Change design basis, due to scale-up impact	Low	50	Accept	0	Low	0	15	50
14	Redesign, for SC furnace	Low	800	Mitigate	0	Low	0	0	50
15	Redesign to add gas-trapping system	Low	1,550	Accept	0	Low	0	0	1,550
16	Rework to add waste streams to design	High	3,000	Mitigate	0	Moderate	0	250	2,300
17	Rework robotic features design	High	7,440	Mitigate	53	Moderate	0	500	2,000
18	Redesign for characterization	High	5,000	Mitigate	176	Moderate	0	600	3,000
19	Redesign to meet requirements of DOE canisters	Moderate	3,000	Reduce	0	Moderate	0	100	3,000
20	Design for new cables	Moderate	400	Mitigate	0	Low	0	0	50
21	Redesign for additional MC&A equipment	Moderate	400	Mitigate	0	Low	0	0	50
22	Redesign, to apply new structural criteria to 105L	Moderate	1,500	Mitigate	300	Low	0	0	700
23	Redesign, per SGS inputs	Low	500	Accept	0	Low	0	0	500
24	Redesign for changes, per DOE/NRC interface	Moderate	200	Mitigate	0	Low	0	0	150
25	Additional utility design features	Moderate	500	Accept	0	Moderate	0	300	500
26	Delays initiating design, awaiting R&D completion	High	5,360	Mitigate	0	Moderate	0	240	720
27	Delays, redesigning for classified process control system	Low	60	Avoid	0	---	N/A	N/A	N/A
28	Add features to meet IAEA	Moderate	500	Mitigate	0	Low	0	0	50
29	Uncertainty in obtaining contingency funds	Moderate	2,000	Avoid	0	---	N/A	N/A	N/A
30	Disposal of bundling tubes	Moderate	100	Avoid	75	---	N/A	N/A	N/A
31	Decontamination of final-product canister	Moderate	500	Avoid	341	---	N/A	N/A	N/A
32	Storage location for depleted uranium	Moderate	100	Avoid	75	---	N/A	N/A	N/A
33	Availability of emergency generator and fuel tank	Moderate	40	Avoid	0	---	N/A	N/A	N/A
34	Redesign for necessary structural supports	Moderate	300	Avoid	225	---	N/A	N/A	N/A
35	**Arithmetic Sums:**		**48,630**		**1,989**		**0**	**3,295**	**21,170**

T&PRA Contingency (at 80% Confidence Level) using Monte Carlo Simulation = $7.371K

Figure III-1. Impact of Risk Handling on Project Cost for TSF Example

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

SECTION B – ASSUMPTION DISTRIBUTIONS AND CRYSTAL BALL® OUTPUT

Crystal Ball Report
Simulation started on 6/7/00 at 12:52:00
Simulation stopped on 6/7/00 at 12:53:50

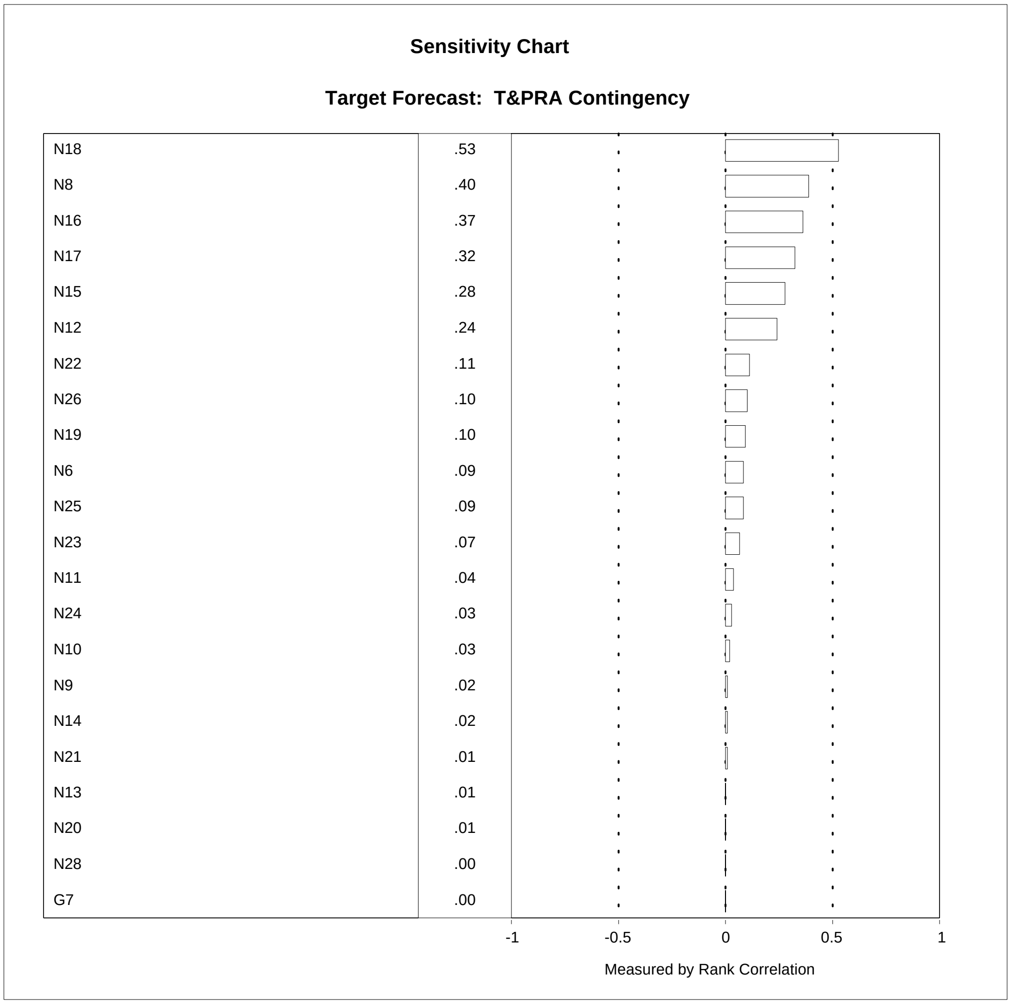


Figure III-2. Crystal Ball® Sensitivity Chart for TSF Example

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

Forecast: T&PRA Contingency **Cell: N35**

Summary:
Certainty Level is 99.90%
Certainty Range is from 3,110 to 10,000 $K
Display Range is from 3,000 to 10,000 $K
Entire Range is from 3,110 to 10,612 $K
After 5,000 Trials, the Std. Error of the Mean is 16

Percentiles:

Percentile	$K
0%	3,110
10%	4,975
20%	5,437
30%	5,754
40%	6,068
50%	6,351
60%	6,647
70%	6,985
80%	7,371
90%	7,896
100%	10,612

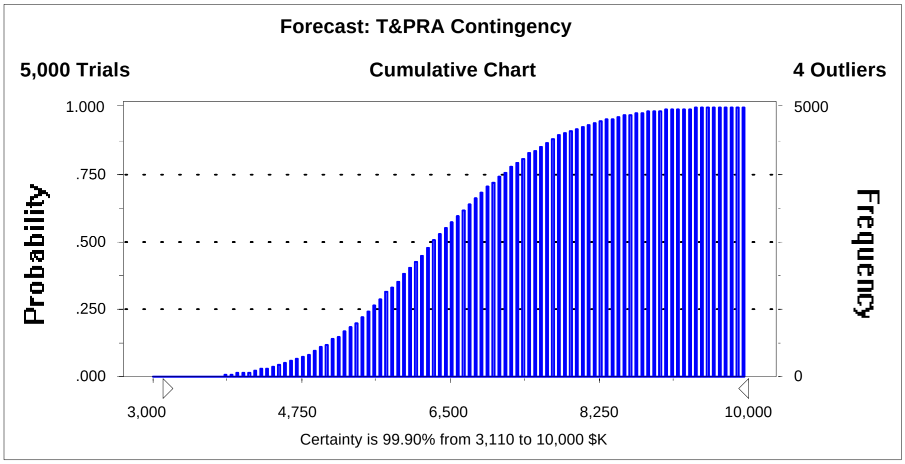


Figure III-3. Crystal Ball® T&PRA Contingency Forecast for TSF Example[4]

[4] The "Cell" designation in Figure III-3 refers to that specific cell in the spreadsheet shown in Figure III-1. This notation also applies to the Assumptions shown in Figure III-4.

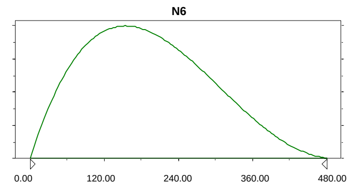
Assumptions

Assumption: N6 **Cell: N6**

Beta distribution with parameters:

Alpha	2.00
Beta	3.25
Scale	500.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 190.12

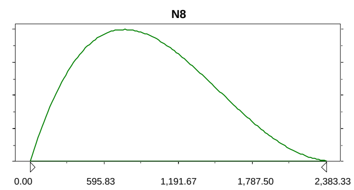


Assumption: N8 **Cell: N8**

Beta distribution with parameters:

Alpha	2.00
Beta	3.30
Scale	2,500.00

Selected range is from 0.00 to 2,465.52
Mean value in simulation was 941.07

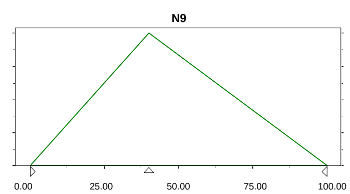


Assumption: N9 **Cell: N9**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	40.00
Maximum	100.00

Selected range is from 0.00 to 100.00
Mean value in simulation was 46.50



Assumption: N10 **Cell: N10**

Beta distribution with parameters:

Alpha	1.00
Beta	4.00
Scale	300.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 59.92

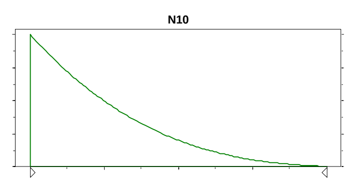


Figure III-4. Crystal Ball® Assumptions for TSF Example

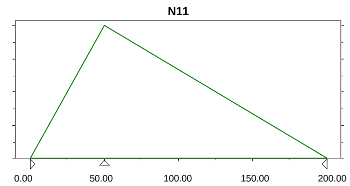
Assumptions (cont.)

Assumption: N11 **Cell: N11**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	50.00
Maximum	200.00

Selected range is from 0.00 to 200.00
Mean value in simulation was 82.71

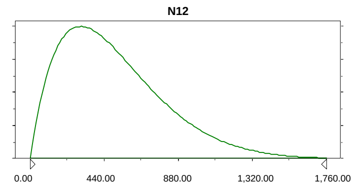


Assumption: N12 **Cell: N12**

Beta distribution with parameters:

Alpha	2.00
Beta	10.00
Scale	3,000.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 507.63

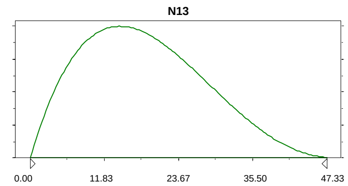


Assumption: N13 **Cell: N13**

Beta distribution with parameters:

Alpha	2.00
Beta	3.50
Scale	50.00

Selected range is from 0.00 to 48.97
Mean value in simulation was 18.27



Assumption: N14 **Cell: N14**

Beta distribution with parameters:

Alpha	1.00
Beta	260.00
Scale	50.00

Selected range is from 0.00 to 60.48
Mean value in simulation was 0.19

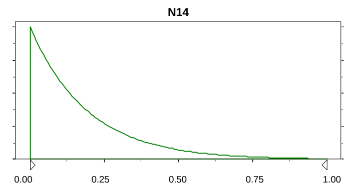


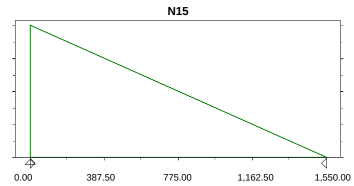
Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

Assumptions (cont.)

Assumption: N15 **Cell: N15**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	0.00
Maximum	1,550.00

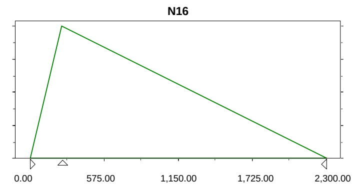


Selected range is from 0.00 to 1,550.00
Mean value in simulation was 519.03

Assumption: N16 **Cell: N16**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	250.00
Maximum	2,300.00

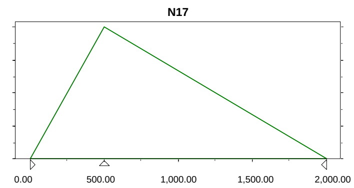


Selected range is from 0.00 to 2,300.00
Mean value in simulation was 841.45

Assumption: N17 **Cell: N17**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	500.00
Maximum	2,000.00

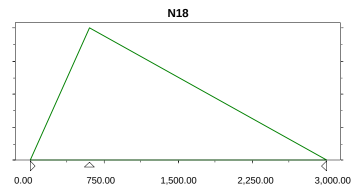


Selected range is from 0.00 to 2,000.00
Mean value in simulation was 840.17

Assumption: N18 **Cell: N18**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	600.00
Maximum	3,000.00



Selected range is from 0.00 to 3,000.00
Mean value in simulation was 1,206.46

Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

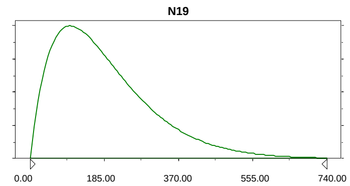
Assumptions (cont.)

Assumption: N19 **Cell: N19**

Beta distribution with parameters:

Alpha	2.00
Beta	30.00
Scale	3,000.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 188.46

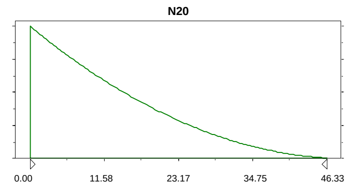


Assumption: N20 **Cell: N20**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	50.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 12.18

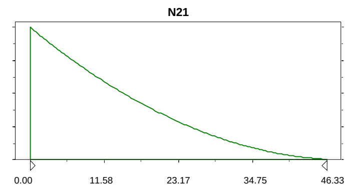


Assumption: N21 **Cell: N21**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	50.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 12.67



Assumption: N22 **Cell: N22**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	700.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 173.03

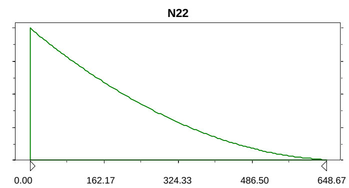


Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

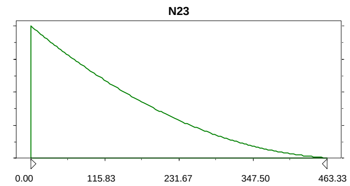
Assumptions (cont.)

Assumption: N23 **Cell: N23**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	500.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 124.00

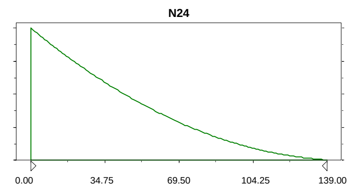


Assumption: N24 **Cell: N24**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	150.00

Selected range is from 0.00 to +Infinity
Mean value in simulation was 36.88

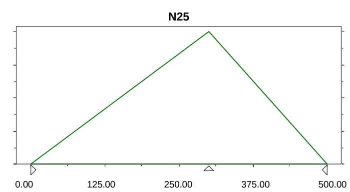


Assumption: N25 **Cell: N25**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	300.00
Maximum	500.00

Selected range is from 0.00 to 500.00
Mean value in simulation was 268.49



Assumption: N26 **Cell: N26**

Triangular distribution with parameters:

Minimum	0.00
Likeliest	240.00
Maximum	720.00

Selected range is from 0.00 to 720.00
Mean value in simulation was 322.70

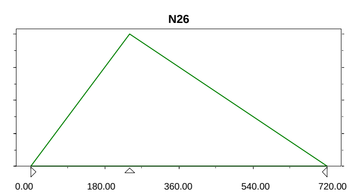


Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

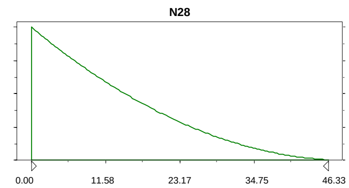
ATTACHMENT III – RISK-BASED COST CONTINGENCY EXAMPLE

Assumptions (cont.)

Assumption: N28 **Cell: N28**

Beta distribution with parameters:

Alpha	1.00
Beta	3.00
Scale	50.00



Selected range is from 0.00 to +Infinity
Mean value in simulation was 12.49

End of Assumptions

Figure III-4. Crystal Ball® Assumptions for TSF Example (cont.)

ATTACHMENT IV – COMBINING TRADITIONAL AND T&PRA CONTINGENCIES

Once the cost impact of residual risks has been identified, this cost – referred to as the T&PRA contingency – may be combined with the traditional contingency and included in the project cost estimate.[5] There are various methods for accomplishing this, the simplest being algebraic addition of the T&PRA contingency estimate and the traditional contingency estimate. A more accurate reflection of this combined value can be established through probabilistic addition of the traditional and T&PRA contingencies.

The most thorough treatment of risk impact is to incorporate the cost associated with each risk directly into the cost of an identified project "item," along with the traditional contingency. For example, assume the estimated cost for procurement and installation of 100 feet of pipe is $1,000. Traditional contingency variables of quantity, unit cost, labor rates, etc. identify a distributed cost of between 90% and 125% of this value, or $900 to $1,250. Project risks, such as unexpected radiological conditions encountered in the construction area, unanticipated underground interferences, lack of integrity of the existing system, etc., identify an addition to the cost distribution of -$0/+$400. This results in a new distributed cost for the cost of the installed piping of between 90% and 165% of the estimated cost of $1000. The primary shortcomings of this method are:

- This cannot be applied unless the WBS levels have been identified in the estimate
- Many risks are identified that do not have a one-to-one alignment with a single, specific project element/WBS entry.

An alternative method for combining traditional and T&PRA contingency is to statistically combined the final distributed project cost estimate, as generated by Project Controls, with the final, distributed T&PRA contingency calculation of all risks identified for the project. If the Project Controls cost estimate is not provided as a distribution function model, an appropriate model is generated to reflect the data. This process is illustrated by the following example.

Suppose that the output generated by a project cost estimate yields the data in Table IV-1 on the following page:

[5] For a more thorough discussion on project contingency, refer to Project Management and Control Methods, WSRC-IM-95-00020, Guide 1.4, Project Contingency.[9]

ATTACHMENT IV – COMBINING TRADITIONAL AND T&PRA CONTINGENCIES

Table IV-1. Output of a Standard Project Cost Estimate

Estimated Project Cost ($50,741K)	
Probability of Overrun (%)	Contingency (%)
84	8.63
80	9.08
70	11.09
60	13.02
50	14.81
40	16.73
30	18.61
20	21.90
16	22.64

Multiplying the estimated project cost by each of the contingency percentage values results in the following confidence level versus expenditure data:[6]

Table IV-2. Project Confidence Level vs. Contingency

Confidence Level (%)	Contingency	
	(%)	($K)
0	5.30	2,689
10	7.20	3,653
16	8.63	4,379
20	9.08	4,607
30	11.09	5,627
40	13.02	6,606
50	14.81	7,515
60	16.73	8,489
70	18.61	9,443
80	21.90	11,112
84	22.64	11,488
90	24.00	12,178
100	26.00	13,193

i.e., if the project is allocated a contingency of $4,379K to increase the estimated project cost to $55,120K, there is a 16% level of confidence that the project is underfunded.

Using the TSF example provided in Attachment III, this data is input into the Crystal Ball® spreadsheet as a probability distribution, and is then statistically summed with the individual T&PRA residual risk distributions using the Monte Carlo simulation. The result of this statistical summation is shown in Figure IV-1 on the following page.

[6] Contingency values for confidence levels below 16% and above 84% were produced by extrapolating existing data.

ATTACHMENT IV – COMBINING TRADITIONAL AND T&PRA CONTINGENCIES

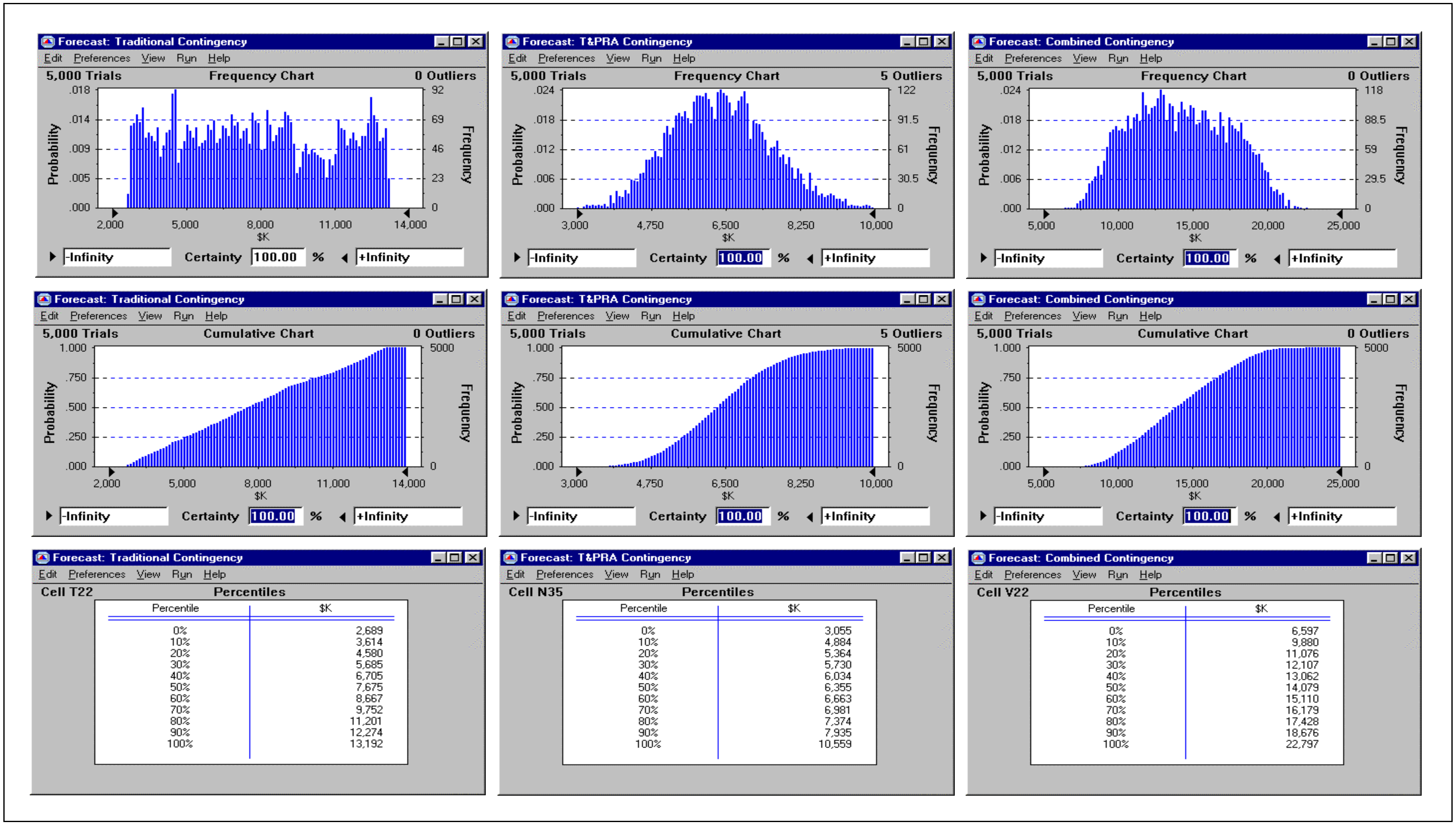


Figure IV-1. Traditional, T&PRA, and Combined Contingencies

Practice 9

9

Communications and Stakeholder Participation

9 COMMUNICATIONS AND STAKEHOLDER PARTICIPATION

9.1 OVERVIEW

The goal of a public participation plan is to align project and public interests so that project decisions reflect community concerns. To ensure the proper level of public participation, planning should begin early, during the project's conceptual phase, so that public participation can be integrated with the decision-making process throughout the project.

To ensure consistency and the most efficient use of public participation resources, the project manager must coordinate all public participation activities through the DOE Headquarters Office of Public Affairs or its counterpart in the field. The Public Affairs staff is experienced in communicating effectively with the public and can help the project manager use existing mechanisms for public participation to gain public input. Such coordination may include consulting with other project managers involved in ongoing public participation activities (e.g., public participation coordinators for Environmental Management projects). This guidance explains how public participation works within the project; however, the project manager should rely on Public Affairs to direct the effort.

In implementing this guidance, the project manager must understand and enact the intent of DOE P 1210.1, Public Participation, which describes the Department's goals and core values for enlisting public input on project decisions.

Accordingly, public participation plans may be tailored to a site or to a specific project. The site-integrated plan covers all project activities at a site. Although small and/or medium-sized projects may be incorporated into the site-integrated plan, a large project (as defined by cost or project duration) may require its own plan. This guidance both lists and explains the minimum components recommended for an effective project-specific communications and stakeholder participation plan, but the principles might be applied to a site-integrated plan as well.

Various communications and stakeholder participation requirements are imposed by the following laws which should be reviewed by the project manager to determine their applicability:

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as revised by the Superfund Amendments and Reauthorization Act (SARA)
- Resource Conservation and Recovery Act (RCRA)
- National Environmental Policy Act (NEPA)

9.2 PRINCIPLES AND PROCESSES

In the past, many public participation programs relied on one-way communication. Officials used presentations, brochures, press releases, and other public information tools to prepare the government's side of the story without inviting public comment. That is no longer the case.

Besides being required in many cases by law, citizens often demand a voice in how, and sometimes if, a project will be carried out. When stakeholders don't have the opportunity to participate, they are much more likely to resist and oppose a project, which can present a serious obstacle to success. When people are allowed to participate in and affect the decision-making process, they are more likely to accept the outcome. In addition, they may be able to share information that increases the likelihood of project success.

Over the course of a project, public attention and interest in the project can change in focus and intensity. The project must establish communications channels through activities that provide the greatest flexibility in reaching audiences and avoid continual creation of new programs. Communications should be based on the project's goals and the need or desire for segments of the public to be involved. Communications tools or activities that when, once established, can be used to address changing messages, issues, and audiences, provide the best opportunity to conduct clear, accurate communications in a cost-efficient manner.

9.3 THE PUBLIC'S ROLE IN DECISION MAKING

Interest in community issues varies widely. Some individuals or groups are intensely interested and will devote considerable time and energy to learning about issues and participating in decisions. Other participate occasionally. Others do not participate at all.

Effective public participation should be tailored so that individuals can participate at their level of interest. Accordingly, public participation plans should provide a variety of opportunities for participation. For the most active members of the public, such activities can include participation in citizen's boards, public meetings and hearings, and one-on-one meetings with project representatives or Public Affairs officers. Less active individuals can be reached through news releases, news conferences, community newsletters, and direct mailings. Such opportunities are discussed in Section 9.6, Public Participation Tool Box.

When overall public interest in project decisions is extremely high or the project is controversial, project managers should be especially mindful of keeping the public informed about the project, including opportunities for participation throughout the decision-making process.

Effective communications and stakeholder participation is especially important when a project generates high levels of public interest or is likely to be controversial. Existing public participation programs provide excellent insight into issues that generate public concern. Examples of such issues include:

- Release of contaminates to air or water
- Transportation of hazardous materials or materials perceived to be hazardous
- Public and worker safety and health
- Future use of a facility
- Cleanup progress
- Budget and costs
- Public involvement, public information, and communication.

The above issues can raise public interest or concern and should be addressed accordingly. Any project with implications concerning safety and health, the use of tax dollars, reduction in the number of jobs, reduction in the value of real estate—any marked change in the status quo—is likely to generate public concern, thus making an effective communications and stakeholder participation program necessary. In addition, the following elements should be considered in gauging the amount of controversy associated with a project:

1. Do advocacy groups already exist for particular outcomes, either within a site or among stakeholders? Such advocates, either internal or external, are likely to generate controversy in an effort to ensure their preferred outcome prevails. In such instances, a forum should be provided so that these individuals, and others with different opinions, can debate their ideas in an effort to resolve the issues.
2. Is the decision primarily a technical choice or does it require one public concern to be weighed against another? Decisions that are primarily technical usually require minimal public involvement. Decisions that require choices between public concerns are more likely to generate interest and controversy.
3. Managers should make informed judgements about which level of activity is appropriate by consulting Public Affairs, other managers who have conducted similar communications and stakeholder participation programs, and major stakeholders who can provide insight into the level of public interest.

9.4 Communications Staff

Although dynamic communications and stakeholder participation programs add to the duties of project managers, most of this effort should be assumed by the communications staff. During the conceptual phase, the project manager should request that a communications staff member be assigned to the project. This individual, whose job is to translate technical ideas into public information, works with the project manager to develop communications plans (see Attachment 1, Sample Communications Plan). This individual should also develop and maintain project-specific summaries of community concerns, based on the ongoing communications and stakeholder participation process.

Communications counselors also help ensure the timely dissemination of factual information to federal, state, and local officials, key stakeholders, educators, the media, and special interest groups, as well as the public.

General communications services include:

- Management of media relations
- Development of written materials (fact sheets, newsletters, etc.) that provide technical, engineering, or environmental information to the public
- Web site development and maintenance
- Graphic design, video production, and photography services

- Review of technical documents for community concerns
- Public opinion research
- Employee communication
- Emergency public information
- Community outreach
- Training in public speaking and risk communication.

9.5 Communications and Stakeholder Participation Plan

Good timing is essential to the successful integration of public participation with the project's decision-making process. If the public does not have the opportunity to provide early input, their information may be received too late to be used effectively, leading them to believe that their interests have been ignored. On the other hand, if they are asked for input too soon, before the project and related decisions are adequately defined, the public may feel their input is meaningless. Either way, the DOE may lose credibility.

For these reasons, it is important to establish the communications and stakeholder participation plan early in the project. The plan should be updated annually to reflect changes in the project and the decision process—and public input.

The plan should define project goals for public participation and may include compliance with laws and regulations. The National Environmental Policy Act, for example, requires that procedures be developed to ensure the "fullest practicable provision of timely public information and the understanding of Federal plans and programs with environmental impact to obtain the views of interested parties." Additional goals include responding to specific community issues, such as land use and health concerns. In so doing, the project manager can seek to reduce or eliminate costly delays caused by public objections. To meet such goals, the communications and stakeholder participation plan should include the level of public involvement needed, the specific interest groups that should be consulted, and the time frame required.

The decision-making process for a particular project or project activity may be simple or complex, but the basic steps of public involvement consist of the following that should be used to develop a communication and stakeholder participation plan, such as to

- conduct a community assessment.
- consult the public.
- identify potential alternatives that deal with public concerns.
- inform stakeholders of the alternatives being considered.
- evaluate and refine the alternatives.
- present the alternatives to the public.
- make a decision.
- evaluate progress continuously and revise the plan accordingly.

9.5.1 Conduct Community Assessment

Community assessments, which are prepared by Communications, identify the public issues most likely to affect the success of the project and the stakeholder groups most likely to participate in—or object to—the decision-making process.

The community assessment, described below, is an invaluable resource during the project. In addition to discussing the structure of the community, the profile may describe

- how the community has reacted to the site in the past.
- what citizen actions have been taken.
- how DOE's approach to communications and stakeholder participation has changed over the years.
- how the community regards the risks posed by the site, focusing on the perceptions of past events and problems.

Identify Stakeholders

The term stakeholder refers to people who are interested in a project decision because of their proximity, economic interest, use of mandate or authority; or their vulnerability to environmental, socioeconomic, or cultural impacts.

Stakeholders may be part of one of more of the following groups:

- U.S. EPA
- U.S. DOT
- Native American Tribal Governments
- State governments
- Local governments
- Elected officials
- Environmental groups
- Industry and professional organizations
- Labor organizations
- Education groups
- Citizens groups
- Educational groups
- Community members

Communications and stakeholder plans should identify which stakeholders are most likely to take an interest in project decisions and commit their time and resources to participate in these decisions. The plan should link specific stakeholder group(s) with specific technical issues, objectives, and/or other significant features of the project. This information can be used to plan for the participation of that group during project implementation, including the timing of their participation, and the size, type, and cost of related activities.

Identify Issues Likely to Affect the Public

To obtain the participation of all major stakeholders, issues should be identified at a level that does not automatically rule out the options they believe should be considered. For that reason, the first step in the communications and stakeholder participation plan may be the initiation of a Citizens Advisory Board to obtain an initial list of the public's concerns. Communications will be instrumental in the success of this effort and can provide valuable information, including public opinion research and community profiles.

If the project manager chooses not to consult with opinion leaders, the team would have to develop alternatives by starting with known technical approaches and combining them in various ways. The project team might be able to decide on one alternative, but by working in isolation from the public would be likely to prejudge major value issues in favor of technical solutions, perhaps failing to account for public concerns. When the team works with various stakeholders, however, they are more likely to consider a broader range of alternatives. In fact, the range of choices may be too broad to allow detailed technical evaluation of each alternative, but stakeholders are far more likely to support the process if they can see that the alternatives considered reflect their concerns.

Typical public issues may include long-term safety, short-term risks, on-site disposal requirements, the impact on natural resources, transportation and off-site disposal requirements, economic impacts and benefits, and cost.

9.5.2 Consult the Public

The communications and stakeholder participation plan should recognize that once the issues are identified and various alternatives are under consideration, the project manager, in concert with communications personnel, should publicly announce the various options and seek comments. Depending on the level of public interest, the best avenue for this discussion may be a Citizens Task Force, a public meeting or hearing, or an announcement in the newsletter with an invitation for comment. At this time, the public may suggest additional alternatives or ways to modify existing alternatives to make them more acceptable. The public may also provide reasons for rejecting certain alternatives. This step may more fully define existing alternatives or extend the list further.

9.5.3 Identify Potential Alternatives that Deal with Public Concerns

To maintain credibility and ensure selection of the best alternative among a range of options, the evaluation process should be as objective as possible, taking into consideration the technical and economic feasibility of alternatives while describing the social, economic, and environmental impacts that would result from each. These impacts should be described so that they are technically verifiable.

Because the number of alternatives may be too great to allow detailed evaluation of each one, this evaluation may necessarily be a rough cut. Based on this rough-cut evaluation, the project team may determine that some alternatives are not feasible technically, have too many unacceptable impacts, or are unacceptable to the public. Accordingly, unacceptable alternatives are eliminated and the possibilities reduced to a number that can be reasonably studied in greater detail.

Determining which alternatives are best is not always easy for the public, or even decision makers. The best alternative for one group may not be the best for another. Cost may be the project manager's primary consideration, for example, while jobs may be the public's primary concern. When the project manager is faced with such choices, public participation is especially important in determining the range of acceptable choices, even though one choice will not please everyone.

9.5.4 Inform Stakeholders of the Alternatives Being Considered

Again, projects managers should use the various public information tools to inform stakeholders and the public what alternatives are being considered, the criteria used to discard some, and retain those most promising. The public can offer additional input to help the project team further evaluate and refine the alternatives.

9.5.5 Evaluate and Refine the Alternatives

Most effective decision-making processes go through several iterations. Each time, some alternatives are eliminated and some are added. With each iteration, the alternatives are defined to a greater level of detail in an effort to select the alternative that best suits the technical and cost needs of the project, while recognizing the public's values.

In making these determinations, the project team and Communications should answer the following questions:

1. What evaluation methodology should be used?
2. Are alternatives consistent with stakeholder concerns?
3. Can the alternatives be modified or combined to better accommodate the various factors affecting decision?
4. Is more information needed to make the decision?

5. If a public concern changed for some reason, would the choice of the alternatives be affected?
6. Is more than one course of action acceptable if the situation changes or if new information makes the first choice unacceptable?

9.5.6 Present Alternatives to the Public

Once again, the public participation plan should provide for a public forum to discuss the alternatives. If uncertainties about the alternatives still exist, they should be honestly presented with some estimate of the time required for resolution. At this point, the schedule should allow for further changes.

9.5.7 Make the Decision

In the end, the project manager is responsible for the decision. Obviously, public participation cannot dictate the decision; even the best public participation programs involve only a small percentage of the public. However, when stakeholders care enough to participate in the decision-making process, their participation should mean something, or they will be more upset than if they had not been asked to participate in the first place. For that reason, it is important that the project manager and the project team work to ensure that the public understands how their concerns were considered. Once again, some public forum must be provided to announce the final decision, along with a clear explanation of the process used to make the decision, the criteria used, and the impact of the decision on stakeholder interests.

9.5.8 Evaluate Progress Continuously and Review the Plan Accordingly

Throughout the project, the project team should evaluate decisions as described above, in addition to re-evaluating decisions already made, so that they recognize and take advantage of any opportunity to accommodate the public.

The evaluation process can be difficult. For one thing, many of the benefits of a communications and stakeholder participation program are intangible and therefore subjective and difficult to measure. For another, the benefits of one public participation activity depend to some extent on the success of other related public participation activities; the credibility established by one group or during one activity may affect another.

9.6 Communications and Stakeholder Participation Tool Box

9.6.1 Public Meetings and Formal Public Hearings

Public meetings provide a two-way exchange between the public and DOE. Public meetings may include a panel of DOE or independent speakers, informal discussions with speakers, exhibits, and a question-and-answer period. Public meetings can also include smaller sessions with technical personnel. Providing video/ satellite conferencing for those unable to travel to the meeting and holding evening meetings are ways to encourage participation in public meetings.

As opposed to public meetings, public hearings follow a more prescribed format and are usually held to fulfill the requirements of laws, regulations, or legal agreements and may be convened by DOE or a regulating agency (EPA, etc.). Hearings provide a formal record of public comments on a specific regulatory document for permit application.

Public meetings and public hearings are very visible and for that reason potentially problematic. Depending on the issue and the public's level of interest, the meeting may be well-attended by both the public and the media. If the project is controversial, the meeting may be volatile. For these reasons, Communications should plan and direct the meeting to help anticipate problems and plan solutions, including innovative approaches that will enhance the exchange of information.

Regularly scheduled public meetings provide for ongoing involvement and discussions of a wide range of topics. Over time, monthly or quarterly meetings foster development of mutual respect and understanding while expanding the information base of both the members of the public and the project.

9.6.2 Citizens Groups

Citizen groups can include a variety of possibilities, such as roundtable discussion groups, work or technical review committees, or Citizen Advisory Groups. Such groups can be established for a specific project, or the project manager can work with groups already established at the site. Such groups are regulated by the Federal Advisory Committee Act (FACA, Public law 92-468). The project manager should be familiar with and ensure compliance with this act.

The single most important component for success for the citizens groups is a sincere commitment by DOE and its contractors to seriously consider the group's recommendations. Citizens groups can provide independent recommendations on key project decisions, but all levels of management must be willing to work directly with a Citizens Task Force and its members. Managers who do not understand the significance of public participation should receive additional training to prepare them for the process. Credibility and trust is most often lost at the working level by managers or engineers who send messages that public input is not important or wanted.

A Citizens Task Force provides real public participation, which may increase public understanding and acceptance of the issues while providing DOE decision-makers with insight. Such a group can help the project manager focus on issues that may be lost in the project decision-making process and require significant local involvement. The Citizens Task Force also provides ready access to a knowledgeable group of stakeholders who can act as a sounding board for important and sensitive issues. Finally, a Citizens Task Force can informally disseminate information to the public.

Members understand that they represent the demographics and socioeconomic conditions surrounding the facility. Members should be encouraged to recognize and understand the groups most likely to identify with them and work to ensure those groups are informed of and involved in board activities.

Although it can represent a full range of public concerns, the Citizens Task Force cannot possibly represent everyone. The Citizens Task Force is not the only stakeholder group that DOE listens to; and the group does not replace any part of a public participation program, but enhances the effectiveness of direct public involvement in decision-making.

9.6.3 Prompt, Factual, Accurate Responses to Inquiries

Whenever members of the public or news media have questions or express concerns regarding site developments, events, cleanup plans, and progress; they have presented DOE with an excellent opportunity to increase the public's understanding and gain favor for the project. The project manager should plan in advance for such inquiries, working with Communications and preparing the technical staff to respond quickly, preferably within 24 hours.

9.6.4 Printed Materials

Printed materials include newsletters, fact sheets, and community and employee publications that provide updates on key activities and events at the site and promote public involvement.

9.6.5 Additional Public Information Tools

A number of other tools are available to the project manager, including

- web sites on project activities
- exhibits at public events
- speakers bureau to disseminate information to community organizations
- open house and regular tours of the facility
- mailings to stakeholders and other community members notifying them of public comment periods or the availability of documents
- videotapes to provide information on project accomplishments
- public reading rooms
- educational activities such as mentoring, internship, and school-to-work programs

9.7 Measuring for Results

During the course of the decision-making process, the project manager may want to quantify comments as a means of evaluating alternatives. Such analysis may provide useful information in determining prevailing public concerns, but it should not take the place of sustained public outreach.

At appropriate intervals, depending on the size of the project and the level of public interest, project managers need to conduct evaluations of their public participation programs. Local colleges or universities may be helpful in gathering community opinions and information for a project. Upfront relationships must be established with these groups; however, before they are enlisted to support a project in such an effort.

Attachment 1

SAMPLE COMMUNICATIONS PLAN

West Valley Demonstration Project
Stakeholder Communications Plan for FY2000

GOAL

The WVDP's goal is to achieve its waste and environmental management objectives as established in the West Valley Demonstration Project Act (Public Law 96-368) in accordance with agreements with involved agencies and organizations. As a responsible member of the local community this requires the WVDP to:

- Provide current, accurate Project information to the public and, specifically, to interested stakeholders
- Respond to stakeholder requests
- Solicit, collect, and consider stakeholder input as part of decision-making.

WVDP COMMUNICATIONS APPROACH

WVDP communications is based on meeting the needs of the many individuals and organizations that are interested Project stakeholders. Communications planning is focused on developing and maintaining channels of communication throughout the community, through which information can be disseminated, input can be received, and responses to requests can be provided.

Communications activities are conducted:

- On a proactive basis to provide information and/or solicit input and involvement
- In response to stakeholder requests.

Whether proactive or responsive, communications must meet stakeholders' needs in terms of content and timing.

Responsibilities

The success of the WVDP communications program depends on the integrated participation of personnel from the Department of Energy, the New York State Energy Research and Development Authority (NYSERDA) project offices, and West Valley Nuclear Services Co. (WVNS).

The organizations' responsibilities are:

- ***West Valley Nuclear Services***

  The WVNS Public & Employee Communications Department is responsible for planning, organizing, conducting, and evaluating the WVDP's communications activities.

  WVNS technical and administrative personnel are responsible for providing the support needed to conduct the planned activities.

- ***Department of Energy***

  Project office staff are responsible for working with involved stakeholders to achieve the Department's WVDP goals.

- ***New York State Energy Research and Development Authority***

  The NYSERDA owns the Western New York Nuclear Service Center where the WVDP is located. Authority personnel are responsible for conducting stakeholder communications regarding certain current and long-term Center management issues for which the NYSERDA is responsible.

Communications Focus for 2000

Communications initiatives in FY2000 will continue to focus on providing information to stakeholders on near-term and long-term work and related WVDP completion issues, and will continue to encourage stakeholder involvement and open discussion.

Key work scopes that will be discussed include:

- Remote cleaning of the high-level waste tanks
- Development of a draft preferred alternative for WVDP completion and long-term site management

- Decontamination and decommissioning of portions of the former spent fuel reprocessing plant
- Low-level waste shipping for disposal
- Preparations for shipment of spent nuclear fuel
- Design and construction of the Remote-Handled Waste Facility.

PLANNED COMMUNICATIONS ACTIVITIES FOR 2000

Historically, stakeholder surveys have proven to be valuable communications tools. Based on the input from the stakeholder survey conducted in 1998 and after consideration of past effectiveness, flexibility, and cost of the various activities, the following primary activities are planned for FY2000:

- ***Stakeholder Survey***

  Following on the successful results obtained from the 1998 stakeholder survey, we plan to conduct another survey to evaluate the effectiveness of the changes in communications activities.

  Required by—Best Management Practice.

  Stakeholder involvement—Members of the local community, schools, elected officials, businesses, participants from the Citizen Task Force and the West Valley Coalition on Nuclear Wastes, the Seneca Nation, and regulatory points of contact.

  Participation—38 stakeholders.

  Value/Justification—Obtaining direct knowledge of stakeholders' level of understanding of site activities and communications is vitally important to the successful execution of Project objectives. Feedback regarding Project activities and mission makes it possible to identify areas for improvement and initiate specific corrective actions.

- ***Quarterly Public Meetings***

  Meetings are held at the Ashford Office Complex in Ashford, N.Y., from 6:30 p.m. to 9 p.m. and are tentatively scheduled for:

December 7, 1999	June 20, 2000
March 21, 2000	September 19, 2000

Required by—1987 Stipulation of Compromise Settlement (Civil No. 86-1052-C) between the Department of Energy and the Coalition on West Valley Nuclear Wastes.

Stakeholder involvement—Open to the general public. Representatives of the Coalition on West Valley Nuclear Wastes, Town of Ashford Board, local media and interested area residents routinely attend.

Attendance—15 to 35 people.

Public Notification—Personal postcards announcing each meeting are sent to regular attendees and key community representatives. Public notices in local newspapers, Penny Savers, WVDP employee newsletter.

Value/Justification—Initiated in 1987, the meetings are open forums to address changing issues and provide routine updates on Project progress. Minimal cost and ongoing attendance by local officials and interested residents make the meetings an excellent means of involving stakeholders.

- ***Citizen Task Force***

In January 1997, NYSERDA, with the support of the DOE, convened a Citizen Task Force (CTF) to provide recommendations regarding completion of the WVDP by DOE, and closure and/or long-term management of the site by NYSERDA.

The CTF is comprised of 16 Western New York residents invited to take part based on their involvement in a wide range of area organizations and groups. CTF members are associated with environmental and civic groups, educational organizations, and business organizations, in addition to representing elected offices and the Seneca Nation of Indians.

Twice monthly meetings were held through July 1998. At the July 29, 1998, meeting the CTF completed their recommendations report on WVDP completion and site closure and/or long-term management, and submitted it to DOE and NYSERDA. The CTF continues to meet to receive updates on EIS-related activities on an as-needed basis.

Required by—Best Management Practice.

Stakeholder involvement—Task Force members, general public, media.

Attendance—10 to 20 people.

Public notification—Pre-meeting mailings are sent to all Task Force members and interested stakeholders that have asked to receive them. Because meetings are scheduled on an as-requested basis, public notices are placed in the local paper. Meetings are frequently covered by the local Springville, NY weekly newspaper.

Value/Justification—The CTF was formed following evaluation of public comments received on the Draft Environmental Impact Statement. Numerous stakeholders commented on the complexity of the issues and the subsequent challenge in comparing alternatives. The CTF is one means of helping local stakeholders better understand the study and the issues involved. The recommendations report that has been submitted not only identifies key issues of community concern, but also provides a basis for discussions between involved stakeholders and the WVDP as a preferred alternative that will be developed over the coming year.

- ***Spent Nuclear Fuel Shipping***

In the coming year, considerable effort will be spent developing a plan for communications activities associated with shipping the 125 remaining spent fuel assemblies to the Idaho National Engineering and Environmental Laboratory in 2001. In addition to the development of the Communications Plan, meetings with state points-of-contact along the transportation corridor will be initiated, outlining both the shipping project and communications activities.

- ***Open House***

Although the date and format have not been identified, Open House 2000 will continue to focus on tours and informational materials that allow visitors to view the WVDP facilities first-hand. Emphasis remains on interim projects that will bridge activities in anticipation of a preferred alternative and decisions about long-term site management.

Required by—Best Management Practice.

Stakeholder involvement—General public, Western New York schools, employees' families/friends/associates, interested/involved stakeholders and media.

Attendance—Over the history of the WVDP attendance has ranged from approximately 600 visitors to 1,800 visitors.

Public notification—Press release, posters, bulk mailing to local residents (4,500), advertisements in western New York newspapers/penny savers, special mailing to interested stakeholders outside the local area.

Value/Justification—Public and media responses have been overwhelmingly positive throughout the years. Results from the stakeholder survey conducted in 1998 showed that Open House is an activity that appeals to a wide range of people and which participants feel is very informative.

In addition, media coverage of the event provides the opportunity to disseminate information to the general public, thus reaching many people in addition to Open House visitors.

► ***Local Chambers of Commerce***

Public and Employee Communications staff attend monthly meetings of the West Valley and Springville Chambers of Commerce to share information with local business leaders on Project and community activities and issues. As appropriate, the Project participates in community related functions of the chambers.

Required by—Best Management Practice.

Stakeholder involvement—Local business owners, site neighbors, elected officials, members of key community organizations.

Attendance—25 to 30 people.

Value/Justification—Monthly meetings are informal and provide opportunity for open dialogue. Featured topics cover the range of local issues and activities providing valuable information to the WVDP on community concerns, as well as providing area leaders routine access to WVDP information. Contacts with many local residents are developed, establishing channels for future communications.

► ***Public Reading Files***

The Public & Employee Communications Department maintains files of key WVDP documents in five locations (four area libraries and at a WVDP facility) to provide the public with open access to information.

Required by—DOE and regulatory guidance.

Stakeholder involvement—Three public reading files are located within 10 miles of the WVDP to meet the needs of residents in the local area. The other two reading files are in the major population centers north (Buffalo, N.Y.) and south (Olean, N.Y.) of the WVDP.

Value/Justification—Document files maintained in public libraries are a very inexpensive means of assuring basic WVDP information is available to the general public.

- ***Educational Programs***

Maximizing WVDP value to the local community has always been a Project goal. The establishment of an educational partnership between the WVDP and area schools is an example of this approach in action.

Two programs that will continue in the 1999-2000 school year are the Educational Horizons Work/Study Program and the Mentoring Program.

The Horizons Program was developed to take advantage of the wide range of technical and administrative disciplines at the WVDP to help students in their senior year make career choices and encourage them to further their education after high school.

Involved students work at the WVDP in situations which match their career interests. The work assignments are integrated into the students' school schedules, with most students at the Project for about eight hours each week. Through the WVDP/West Valley Central School partnership, additional private businesses are now taking part and will provide assignments for two students this year.

The Mentoring Program was begun in the 1994-95 school year and brings adult mentors into the school to meet and work with junior and senior high students on a weekly basis.

Students offered the chance to take part are selected by school staff based on the potential value of additional support and assistance to their success in school. They meet once a week in school with their adult mentor.

In the 1999-2000 school year, the mentoring program will be offered at Springville Middle School as well as Saint Aloysius in Springville and West Valley Central School. The WVDP will continue, in cooperation with the West Valley Central School Partnering Committee, to focus on soliciting the involvement of other area businesses to provide more opportunities for students.

Required by—Best Management Practice.

Stakeholder involvement—Three students are enrolled in the Horizons Program and 27 employees are participating in the Mentoring Program for the 1999-2000 school year.

Value/Justification—The programs provide opportunities in a rural area that would not be available to local students without the WVDP's participation. At a very minimal cost, students benefit through enhancement of their education, and WVDP employees expand their perspective on the importance of the WVDP to the community and develop their interpersonal skills.

Routine Communications Functions

The following activities are conducted to respond to public requests. The WVDP Public & Employee Communications Department will continue to fulfill these responsibilities.

- Responses to Public and Media Information Requests
  — More than 200 annually
- Site Tours and Briefings
  — 30 to 60 annually
- Off-site Presentations for Educational and Community Organizations

WVDP Stakeholders

- Citizen Task Force (CTF)
- Coalition on West Valley Nuclear Wastes (CWVNW)
- Seneca Nation of Indians
- Government: New York State, Cattaraugus and Erie County, Towns of Ashford and Concord
- Regulatory agencies: NRC, EPA Region II, NYS Department of Environmental Conservation, NYS Department of Health
- Regional residents
- Local media
- National media—spent fuel shipping campaign
- Employees

Current Public Affairs Environment

Many of the public outreach activities performed over the last year have maintained, and in a number of areas improved, relations with members of the local community. The Project continues to provide support to the community through educational programs, participation in local chambers of commerce, and various information sharing activities. In the Western New York region, the Project is currently experiencing a period of strong public acceptance.

Analysis

During the first ten years of the Project there was interest throughout the Western New York community in the WVDP. Initially there was general fear of the site due to misconceptions that had developed over nearly two decades of a "closed door" policy. After the WVDP "opened the doors" and alleviated many public fears, stakeholders focused on the real issue of safely solidifying the very radioactive liquid high-level waste. By 1993-94, the vitrification system had been developed, thoroughly tested, and as final preparations for vitrification operations proceeded public concern and attention became somewhat dormant.

By the time actual processing began in 1996, there were <u>no</u> public concerns voiced and it was very difficult to garner media coverage in Western New York after the initial startup of the facility. The West Valley site had faded from public awareness.

This general public calm and acceptance can be deceptive. When the public and the media are presented the plan for completing the WVDP and managing the site for the long-term, the West Valley "story" will be "new" again. The issues of long-term environmental dangers, regional equity, institutional controls, and state versus federal responsibilities all are issues that can incite negative public reactions and can become social obstacles to completing Project activities.

For example, when DOE began planning cleanup at the Tonawanda FUSRAP site, DOE held public meetings to discuss proposed alternatives. When DOE announced that the preferred alternative was to perform partial excavation and dispose of the material on site, the public was not satisfied. Due to strong public objections, the preferred alternative was changed to partial excavation and off-site disposal. Significant delays resulted.

We have identified this potential and have increased outreach activities to include a larger audience to prevent this kind of negative result. Following is a list of activities that were targeted in fiscal year 1999.

- ***Stakeholder Survey***

  The WVDP has always worked to provide opportunities for open communications all interested stakeholders. The stakeholder survey was conducted to collect feedback from individuals that have actively participated in communications programs. Questions were developed to gather stakeholders' input on the following specific topics: WVDP mission performance, the overall communications program, and specific WVDP communications activities.

There were two primary goals in gathering the information. The first goal was to determine general stakeholder satisfaction with WVDP operations. The second goal was to gather stakeholder input on specific communications activities to determine the relative value of each and identify possible areas of improvement.

Individuals were selected that actively participated in one or more of the WVDP outreach activities. Individuals were chosen from the Coalition on West Valley Nuclear Waste, the Seneca Nation of Indians, West Valley Central School Parent/Teacher organization, West Valley and Springville Chambers of Commerce, area elected officials, West Valley Volunteer Hose Company, League of Women Voters, area news organizations, Cattaraugus County Industrial Development Agency, Environmental Management Council, Department of Environment and Planning, area residents, Nuclear Regulatory Commission, Department of Environmental Conservation, and the West Valley Citizen Task Force. Information about the surveys was mailed to 38 individuals. Follow-up phone calls were placed to arrange face-to-face interviews at the interviewees convenience and choice of location. All information was kept confidential.

As indicated earlier, the Project seems to be enjoying a period of strong public acceptance. In general, the survey results corroborate the current community relations environment. A summary of the results follows:

<u>Mission Performance</u>—Overwhelming favorable responses for vitrification operations; somewhat less favorable responses for the Environmental Impact Statement-related performance.

<u>Overall Communications</u>—Consistently positive responses regarding the effectiveness and availability of Project information and management.

<u>Specific Communications Activities</u>—Although most communications activities received very positive marks, a review of the remarks provided by stakeholders regarding three communications activities provided insight into improvements that could be made. These three activities/tools were the Public Reading Rooms, Quarterly Public Meetings, and the annual Open House.

Where feedback from the survey had a direct impact on communications strategies, text boxes have been inserted to highlight the stakeholders' concerns. The accompanying text indicates the revision in communications activities that resulted from stakeholders' concerns.

- ***Media Coverage***

A review of the WVDP media coverage in the first six months of this fiscal year revealed a limited number of media contacts. This was primarily due to the fact that the media was kept informed of Project progress, and "business as usual" isn't generally considered newsworthy by news editors.

In the second half of the fiscal year, as work shifted towards projects that will transition the project from vitrification operations to long-term site cleanup and closure activities, specific efforts were made to heighten media coverage. This effort led to increased media coverage of new project cleanup preparations, culminating in extensive coverage of our contaminated groundwater remediation project on the north plateau. And we have taken advantage of each media opportunity, regardless of topic, to communicate the message that long-term site cleanup/closure decisions are pending.

- ***Open House***

Survey Input **-** Stakeholders noted that more encompassing tours of the site during Open House would be beneficial for the public in understanding some of the long-term site management challenges.

Upon consideration of declining attendance at the annual Open House, the focus was shifted away from the traditional approach, which primarily addressed local community members. The concept was refocused toward connecting the already successful community and the educational outreach activities to create a new package to deliver the Project's messages. The result was a very successful two-day event in early May that attracted more than 1,200 visitors. The event met the needs of both the general public and schools and extended the Project's reach to communities and schools outside our usual outreach base.

- ***Visits by Elected Officials***

Recognizing the Project's need for collaborative support from federal and state-elected officials, we intensified our efforts to raise their level of awareness about the Project. This was accomplished through site visits, not only by officials from this district, but officials from adjacent districts as well. The following elected officials have visited the WVDP:

—May 4 US Congressman Amo Houghton

—Staffer for US Senator Daniel Moynihan

—July 30 New York State (NYS) Senator Pat McGee

—NYS Assemblyman Dan Burling and staff

—NYS Assemblywoman Catherine Young

—August 18 Staffers for Congressman Houghton and Senators Moynihan and Hollings

—August 25 US Congressman Jack Quinn and staff

Additionally, since Congressman Quinn's visit, he has assigned Ron Hayes to act as a liaison between the Congressman's office and the WVDP.

On a local level, the Public and Employee Communications department has participated in both the West Valley and Springville Chambers of Commerce. Participation in the Springville Chamber of Commerce has increased significantly.

► ***Visits by DOE Officials***

On March 17, Jim Turi, DOE-Headquarters attended a Citizen Task Force meeting to introduce DOE's "vision" for site cleanup activities. This presentation was provided at the request of the CTF for feedback from DOE on the CTF's recommendations. Feedback from CTF members indicated that they appreciated the effort by DOE to keep the CTF informed of the direction DOE is taking during this difficult decision-making period.

On May 4, 1999, Secretary of Energy Bill Richardson visited the site. Stakeholders were invited to listen to the Secretary's remarks, and came away with the impression that senior DOE management is listening to stakeholder concerns and considering those concerns in the decision-making process. During that same visit, Secretary Richardson committed to completing the negotiations between DOE and New York State over future project responsibility.

A month later, on June 21, the new Ohio Field Office Manager, Susan Brechbill, met with stakeholders during a visit to the WVDP. This continued senior management attention reinforces stakeholders' confidence in DOE.

- ***Tribal Relations***

Progress has also been made in work with the Seneca Nation of Indians. Recent communications successes include the completion of radioactive waste transportation orientation sessions. This activity was included in the Cooperative Agreement between DOE and the Seneca Nation to examine the possibility of shipping radioactive waste across Seneca lands.

- ***Quarterly Public Meetings***

Survey Input—A number of comments were received that more information and communication emphasis should be placed on long-term waste and facility management challenges.

In the past couple of years, topics addressed at the Quarterly Public Meetings focused on updating the public about vitrification design, construction, and operation. Based on feedback identified in the stakeholder survey, topics for the more recent meetings have refocused on EIS-related messages.

- ***Educational Outreach***

This is an area in which the WVDP has always excelled. In addition to the traditional school tours and presentations, the Project supports several educational outreach activities.

Mentoring Program
One-on-one mentoring sessions between Project employees and local elementary and middle school students. On average, more than 30 employees participate.

Horizons Program
Work/study program for seniors from three area high schools that provides real life work experience to students.

Historically Black Colleges and Universities (HBCU)
Since 1995, the WVDP has actively recruited students from HBCUs to participate in the summer student program.

Buffalo Engineering Awareness for Minorities (BEAM)
This organization has been supported by the Project through the traditional means of providing tours and presentations, but also by providing technical advisors. A Human Resources representative is on the BEAM Board.

Buffalo Elementary School of Technology (BEST)
Two years ago, the WVDP adopted an elementary school in the city of Buffalo. In addition to supplying technical advisors and providing tours and presentations about the WVDP, employees have participated in *Teacher for a Day* and *Career Day*.

DOE Academic Achievement Awards
Each year, DOE presents awards to students from three area schools who demonstrate excellence in the study of science, for a total of 12 awards. This year the awards were presented to students by Secretary of Energy Bill Richardson.

Liaisons with Universities
The University of Buffalo played a major role in the development of a permeable treatment wall that was recently installed to stem the flow of contaminated groundwater at the site. UB members performed extensive testing on how the barrier material will perform.

A new relationship with St. Bonaventure University is under development. The WVDP will help sponsor outreach and recognition efforts for S. Bonaventure's School of Journalism and Mass Communication in return for public relations and communications consulting services for the WVDP. Additionally, in the next several months, plans are underway to establish a similar relationship with Buffalo State.

► ***Public Reading Files***

Survey Input—Stakeholders that had used the reading files suggested that reorganizing the documents might assist individuals in locating information more easily.

The Public Reading files were reorganized, labeled and an updated directory was developed. Additional EIS-related documents will be added to the Reading Rooms as they become available.

► ***Community Citizenship***

Considering the small site population, the spirit of giving to the community is immense. When the annual Food Drive began in 1989, Project personnel donated 665 pounds of food for local food pantries. In November 1998, that

> level was raised to 43,840 pounds—more than 22 tons of food. That donation helped feed 677 families in our region. United Way participation has also steadily increased over the years. Last year WVDP employees contributed $94,000 to the United Way, an increase of 7 percent.

In the past, the WVDP has attended both the West Valley and Springville Chambers of Commerce, but over the past year, WVDP participation in the Springville Chamber of Commerce has increased significantly. As a member of the Springville Chamber Board, a WVDP representative led a campaign to raise funds for the area Christmas lights, successfully raising more than five thousand dollars.

The prime contractor, Westinghouse, was sold to Morrison Knudsen this past summer. This activity, which could have had significant on the Project and on outreach activities, was completed seamlessly.

SUMMARY

Although current communications strategies seem to be working, we must continue to guard against benign neglect—in other words, we need to be careful not to assume a false sense of security.

With that in mind, we're going to continue doing the community outreach activities that have worked for us in the past such as Quarterly Public Meetings, Open House, educational outreach, tours and presentations. But as the Project nears decision-making regarding site cleanup and closure, we will pursue opportunities and apply innovative methods for communicating the Project's messages and developing strong community relationships and support.

Practice 10

10

Project Control

(EVMS, Performance Measurement, and Reporting)

10 PROJECT CONTROL
(EVMS, PERFORMANCE MEASUREMENT AND REPORTING)

10.1 OVERVIEW

The simplest definition of a successful project would be a project that is completed within the scope, schedule, and cost baselines, and delivers the required technical performance, thus fulfilling the mission needs specified in the justification for the project. The primary elements involved in ensuring success include planning, budgeting, scope execution, performance measurement (analysis, forecasting, and reporting), and developing and implementing corrective actions as needed. In principle, these elements are addressed by all organizations for all work (including non-project work) under the umbrella of management control systems and practices. While DOE is not prescriptive in specifying and/or imposing a single system, the project management system is expected and required to comply with the criteria established in this manual.

The DOE has adopted the industry standard ANSI/EIA-748 "Earned Value Management Systems" (EVMS), supplemented with additional DOE requirements and practices as needed, as the core basis for its program and project management systems requirements.

The EVMS criteria are similar to the cost schedule control system criteria (CSCSC) and DOE Order 4700 required by DOE in the past. Contractor systems that were formally recognized by DOE as meeting the 35 Cost Schedule Control System Criteria will be considered compliant with the 32 EVMS criteria.

In contrast to earlier CSCSC and O 4700 implementations, EVMS implementation should be tailored (degree of rigor, detail) to the needs of the program/project depending upon its size, complexity, importance, and cost.

This section summarizes the overall requirements of the project/program management system including EVMS and performance measurement and reporting.

The EVMS concept is designed to provide insight into how a project progresses from a management (federal and contractor) point of view. The EVMS implementation is directed at providing cost and schedule performance data which

- relate time-phased budgets to specific contract tasks and/or statements of work.
- indicate work progress.
- properly relate cost, schedule, and technical accomplishment.
- are valid, timely, and auditable.
- supply managers with information at a practical level of summarization.
- are derived from the same internal Earned Value Management System (EVMS) used by the contractor to manage the contract.

10.2 Performance Measurement

Formalized methodology for cost-effective implementation of performance measurement (PM) on a project should achieve the following objectives:

- Enable the contractor to depict the work plan for subsequent monthly assessments
- Analyze the current performance status and forecast impacts to work scope, schedule, or cost baselines
- Provide data needed for required DOE reporting and internal (contractor) progress reports.

An effective performance measurement process exhibits the following characteristics:

- The process is accepted and documented (formalized)
- Implementation adequately addresses the needs for measuring and reporting performance against the work scope, cost, and schedule baselines
- Implementation is integrated with and reflects the cost and scheduling system baselines, budgeting and cost estimating, separation of funding sources, and types of funding (capital versus operating)
- Baseline change control systems and procedures are in place
- The separation (identities) of projects are maintained and are consistent with organizational and work breakdown structures
- A risk-based tailored approach is used in establishing performance measurement and control requirements in consultation with DOE

10.3 Performance Measurement Tailored to Project

Cost effective application of the performance measurement process requires using a risk-based tailored approach to establish requirements for performance measurement application. A risk analysis is performed on programs/projects or scopes, considering factors such as complexity, dollar value, technology, regulatory requirements, and federal-state agreements, to assess the likelihood and consequences of impacting the workscope's scope, cost, and schedule baselines. This risk analysis forms the basis for establishing the level of detail and the rigor and degree of control exercised in the application of performance measurement. The primary objective of this approach is to maximize program/project control effectiveness at the least cost.

10.4 Performance Measurement Parameters

One or more of the following parameters may be used for performance measurement depending on the nature and importance of the scope.

- Earned Value. A quantified (in dollars) methodology where the "percent of work scope completed" is applied to the total budget for that scope (budget-at-completion, [BAC]) to determine the "earned value" or budgeted cost of work performed (BCWP).

The budgeted cost of work scheduled (BCWS) is a quantified (in dollars) representation of the schedule, being the time-phased (e.g., by month) budget for that scope. A comparison of the BCWP and BCWS may then be used as a schedule performance indicator, while a comparison of the BCWP with the actual cost of work performed (ACWP) serves as a cost performance indicator.

- *Level-of-Effort (LOE).* The time-phased budgets for LOE activities are planned so that at the end of each reporting period, the BCWP is set equal to BCWS. The advantage is that when combined with the discretely planned earned value scopes, all of the budget-scopes for a project are included. This application requires that schedule performance be measured by other parameters (milestones or performance indicators). However, comparison of BCWP (BCWS) with ACWP provides budget versus spending trends and may be used for preparing estimates-at-completion (EAC).

- *Milestone Reports.* The scopes of work to be executed are organized at appropriate levels of detail, milestones are identified, and planned completion dates are established. Monthly (periodic) statusing of the milestones consists of depicting: (a) completed milestones, and (b) forecast completion based on current progress/performance.

- *Technical Progress Indicators.* A product or production-oriented parameter is one where the quantified progress-to-date is compared to the time-phased plan for execution of work scopes for measuring schedule performance. Examples of technical performance indicators include gallons processed, drums produced, tons of soil removed, or cubic yards of concrete placed. Whereas technical performance indicators are an accurate measurement of schedule performance, they do not provide any direct cost performance measurement. However, progress-to-date and forecast schedule completion dates can be used to assess cost impacts.

- *DOE Required Performance Indicators*. Required performance indicators are quantified parameters (similar to technical performance indicators) for which reporting to DOE is a requirement. These indicators may be time-phased or have a single-valued goal against which performance-to-date is measured, Examples include health and safety (collective radiation dose, number of skin contaminations, number of OSHA-reportable incidents); environmental releases (airborne or liquid, radionuclide, hazardous or regulated pollutant effluent releases); hazardous waste inventory; or volume of (solid)/hazardous waste generated at each DOE site.

- *Supplemental Performance Indicators*. Parameters developed by the contractor at each site that are similar to technical performance indicators and DOE-required performance indicators, but are either for contractor use or pertinent to a specific project.

The performance measurement process serves as the foundation for effective project control for both the DOE and the contractor.

From a site integration perspective, the performance measurement methodology for the various projects at a site must have commonality, flexibility, and versatility to enable sitewide integration of performance data as the site management needs evolve.

10.5 Performance Analysis and Reporting

Several different parameters and methods are applicable in reviewing project progress and performance; analyzing the differences (variance) between actual and planned accomplishments; assessing impacts to work scope, schedule, and cost baselines; and reporting progress to DOE.

The performance and progress review must be a periodic, formalized, documented process with three primary objectives:

- Determine current performance status by comparing actual versus planned accomplishments as represented in the performance measurement baseline.
- Forecast expected completion dates and costs; analyze the potential impacts to work scope, schedule, and cost baselines; and, develop and present corrective action plans when needed to minimize adverse impacts to these baselines.
- Periodically review project performance with cognizant DOE personnel and document project status through formal progress reports.

10.6 Responsibilities

Project Managers. Develop performance and progress reporting requirements in consultation with DOE consistent with a tailored approach. The performing organizations and the cognizant managers have the primary responsibility for ownership and integrity of the performance and forecast estimates-at-completion data. The administrative responsibility for integrating and reporting progress and performance analysis lies with the planning and budgeting function.

A tailored approach aims at a cost-effective implementation of the performance analysis and reporting effort by analyzing the project or scope; by developing milestones, indicators, and estimates; by identifying the critical path; and by forecasting schedule and cost, taking into account the size, complexity, cost, and criticality of the project:

- *Analyzing Program, Project, or Scope.* Jointly with DOE, analyze the relative importance of programs and projects and/or scopes within individual programs and projects based on mission importance, complexity, risk, degree of uncertainty, size (dollar value), and number and state of technologies needed. This analysis is a basis for developing a multi-level hierarchy of variance thresholds and reporting requirements appropriate for individual projects, and the contractor's internal lower-level performance analyses. Thus, the lowest thresholds may be appropriate for the contractor's internal performance and variance analysis at the work-package or cost-account level. However, the highest or broadest thresholds may be more appropriate to justify site-wide exception reporting.

- *Developing Milestones, Indicators, and Estimates*. Milestone, performance indicators, and cost estimates are developed jointly with DOE. These milestones, indicators, and estimates are either DOE-controlled baselines or representative of commitments to state or local agreements or to regulatory requirements. These baselines or commitments establish the site-level equivalents of the L0-L3 multilevel baseline concepts.
- *Identifying Critical Path.* Scopes and variances that are on the critical path or that are otherwise judged to be important and that have the potential for significantly impacting work scope, schedule, and cost baselines are identified.
- *Forecasting Schedule and Cost*. Applicable techniques for forecasting schedule completion (for milestones) and cost estimates-at-completion (for scopes) range from expert opinion or judgement for lower risk, less important scopes, to detailed bottom-up resource-loaded critical-path scheduling for the higher risk, more important scopes.

10.7 Performance Analysis

10.7.1 Earned Value Analysis

- *Schedule Variance.* Based on earned value performance measurement, schedule variance (calculated as BCWP–BCWS), is a dollarized depiction of the schedule status as compared to the plan. Schedule variance analysis is used in combination with the applicable milestone completion forecasts for assessing potential impacts to baselines or to controlled, reportable milestones, and to establish whether any corrective actions are needed. Lower thresholds may apply to critical path or near-critical path activities, higher thresholds to non-critical activities.
- *Cost Variance.* The cost variance, calculated as BCWP–ACWP, is an indicator of expenditures measured against completion of corresponding work scopes. While individual cost variances that exceed predetermined thresholds are analyzed for potential impacts to cost baselines, the aggregate cost variance for a particular project is of greater importance for ensuring that authorized funding ceilings are not exceeded by the sum of both expenditures and commitments (encumbrances).

Note: EVMS implementation does not require that earned value be used for fixed price contracts, time and materials contracts, or level-of-effort support contracts.

10.7.2 Level-of-Effort (LOE) Analysis

The LOE work scopes, by definition, do not exhibit any schedule variance. Work scopes that have important schedule milestones should either be planned or be appropriately reflected in the milestones for tracking progress.. Analysis of the cost variance for LOE work scopes is an important factor in preparing an estimate-at-completion forecast and staying within the funding ceiling for expenditures and commitments.

10.7.3 Milestone Analysis

The milestone baseline commitment date, along with the forecast completion date, is the most direct and effective parameter for schedule performance measurement and analysis. The difference between planned and forecast completion dates is referred to as a schedule-time variance. Schedule variance analysis thresholds are generally set at 30 days. Cost impacts due to predicted late completions and/or corrective actions for schedule recovery should be reflected in the cost estimate-at-completion for the corresponding work scope.

10.7.4 Technical Progress and Performance Indicators Analysis

Technical progress and performance indicators are safety-, environmental-, and production-oriented parameters. In some cases there may be associated milestone commitments. Forecast completion dates for milestones should be consistent with current performance. If corrective actions are needed to meet production milestone commitments, this should be reflected in the forecast estimates-at-completion for corresponding work scopes.

10.8 PERFORMANCE/PROGRESS REPORTING

- Progress Review Meetings
  The consolidated site monthly progress and performance review meeting represents a disciplined, formalized, and documented approach to the analysis and presentation to the DOE of performance and progress. This presentation includes an overview of the project; a breakdown by funding categories, such as capital and operating ; and project status, progress, and needs. Consistent

with a tailored approach, selected major projects may be reviewed monthly, with smaller projects being reviewed quarterly or semiannually.

The presentation to DOE may be preceded by an internal contractor review at which the contractor project manager reports progress to senior management and staff.

- *Progress Reports.* A formal project progress report is issued monthly and includes safety performance, status of DOE controlled and reportable milestones, budget and costs, progress status, and variance reporting.

  The Federal program manager's report should be issued quarterly (monthly if required by DOE-HQ).

- *External Factors*. Several external factors not related to performance could significantly impact the project scope, schedule, or cost baselines. These factors include changes in funding, budget reductions, new regulatory requirements, or new agreements with state or regulatory agencies. Potential impacts from such external factors are analyzed and reported as needed in consultation with the DOE.

DEFINITIONS, METHODOLOGY AND PERFORMANCE ASSESSMENT

Earned Value

Earned Value reflects the integration of cost, schedule, and technical work into one common view to establish a project plan. It uses progress against previously defined work plans to forecast such important concerns as estimated completion costs, finish dates, and the effectiveness of corrective action plans. Earned Value is the measurement of what you physically got for what you actually spent, or the value of work accomplished. "Earned Value" is a term that is often referred to as Budgeted Cost of Work Performed. Simply put, it is a program management technique that uses "work in progress" to indicate what will happen to work in the future.

In a graphical representation of the Earned Value approach, the cumulative Budgeted Cost of Work Scheduled or planned accomplishment is the baseline for the project. The Actual Cost of Work Performed is just the cost as a function of time. The Budgeted Cost of Work Performed or actual accomplishment known as Earned Value is a dollar representation of what it should have cost to do the work already accomplished. From this information, it is easy to calculate the cost variance and the schedule variance of the project at any point in time. It allows us to use cost and schedule to determine where we are instead of using them separately and missing the total picture. Figures A-1 and A-2 show the graphical representation of the data collected using this process.

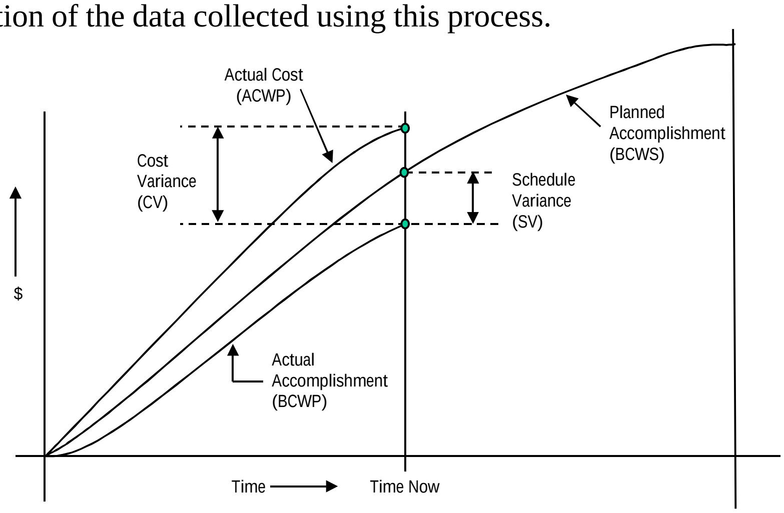


Figure A-1. Data Needed for Earned Value Determination

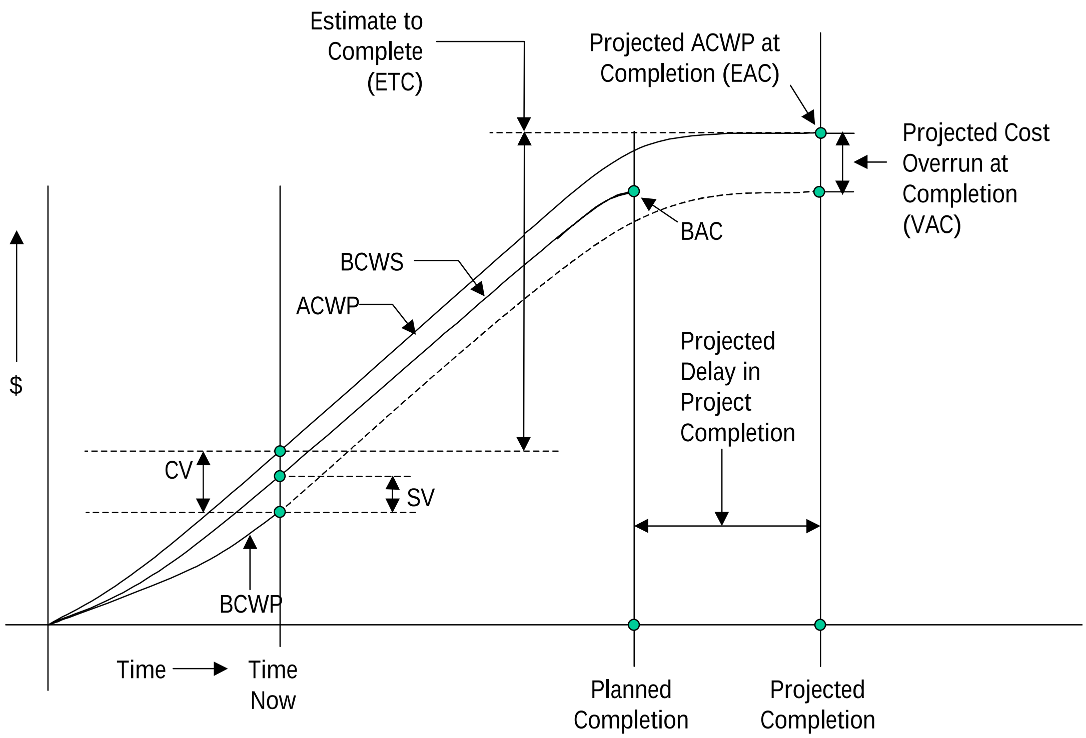


Figure A-2. Earned Value System Parameters

Performance Assessment

The primary performance measures for the Earned Value method are the Cost Performance Index and the Schedule Performance Index. The Cost Performance Index is the ratio between Earned Value and actual costs while the Scheduled Performance Index is the ratio between Earned Value and planned work (budgeted costs). The formulas are shown below:

Cost Performance Index (CPI) =

Earned Value/Actual Cost = BCWP / ACWP

Schedule Performance Index (SPI) =

Earned Value/Planned Value = BCWP/BCWS

If CPI = 1.0, then performance is on target.

If CPI > 1.0, then performance is exceptional.

If CPI < 1.0, then performance is substandard.

The same is true for Schedule Performance Index. Note that a Cost Performance Index of 0.85 means that for every dollar that was spent, only $0.85 in physical work was accomplished. A Schedule Performance Index of 0.90 means that for every dollar of physical work the project had planned to accomplish, only $0.90 was completed.

Other factors that can be used to assess the performance of projects include Cost Variance, Schedule Variance, Percent Variance, Variance at Completion, and To Complete Performance Index.

Estimating Future Cost and Completion Dates

The cost and schedule indices can be used to estimate the approximate cost at completion of the project and the time that it will take to complete it. For cost, we can calculate the Estimate at Completion within a given range of values. The calculations are as follows:

$$\text{Estimate at Completion } (EAC)_{min} =$$

$$(BAC - BCWP) + ACWP$$

$$\text{Estimate at Completion } (EAC)_{max} =$$

$$((BAC - BCWP) / (CPI \times SPI)) + ACWP$$

(Note that there are a number of different Estimates at Completion equations that can be used. See definitions and formulas.

The estimated time to complete the project can also be calculated by taking the projects planned completion in months and dividing it by the Scheduled Performance Index. Therefore:

$$\text{Estimated Time to Complete (ETC) = Planned Completion / SPI}$$

Note that a straightforward extrapolation of the CPI, SPI for estimating project completion assumes no intervention or corrective action (i.e., future performance is similar to past performance).

Performance Measure Definitions and Formulas (See Figures A-1 andA2)

Actual Cost of Work Performed (ACWP). The cost actually incurred during the accomplishment of work performed.

ACWP. See Actual Cost of Work Performed.

BAC. See Budget at Completion.

BCWP. See Budgeted Cost of Work Performed.

BCWS. See Budgeted Cost of Work Scheduled.

Budget at Completion (BAC). The sum of all budgets allocated to a project excluding contingency.

Budgeted Cost of Work Performed (BCWP). Also known as "Earned Value." The sum of all budgets for completed work and the completed portions of open work. (What was budgeted for the work that actually took place?)

Budgeted Cost of Work Scheduled (BCWS). Also known as "planned value." The sum of all budgets for all planned work scheduled to be completed within a given time period. (The cumulative Budgeted Cost of Work Scheduled gives us the performance measure baseline.)

Cost Performance Index (CPI). Represents the relationship between the actual cost expended and the value of the physical work performed. CPI = BCWP / ACWP.

Cost Variance (CV). The difference between Earned Value and the actual costs (ACWP). CV = BCWP - ACWP.

Cost Variance Percent (CV%). The cost variance as a percent of the Earned Value. CV% = (CV / BCWP) x 100.

CPI . See Cost Performance Index.

EAC. See Estimate at Completion.

Earned Value. What you physically get for what you actually spent; the value of work accomplished; the measured performance; the Budgeted Cost for Work Performed.

Estimate at Completion. The projected final cost of work when completed.

EAC = (BAC - BCWP) + ACWP

(assumes 100% productivity for remaining work)

OR

EAC = [(BAC - BCWP) / CPI] + ACWP = BAC/CPI

(assumes same productivity for remaining work as experienced to date)

OR

EAC = [(BAC - BCWP) / (Performance Factor)] + ACWP

Note: A performance factor can actually be weighted to account for the fact that schedule performance is more relevant at the beginning of the project and cost performance is more relevant toward the end of a project. Factors can be based on performance to date or the last several reporting periods.

Performance Factors for Estimate at Completion Equation.

Cost Performance Index: Assumes cost productivity rate experienced to date.

CPI x SPI: Combination of cost and schedule productivity rates experienced to date. This produces the worst case Estimate at Completion. (Example: EAC_{max} = [(BAC - BCWP) / (CPI x SPI)] + ACWP).

0.8 SPI + 0.2 CPI: Weighted combination of cost and schedule productivity rates experienced to date. Used at the beginning of an effort.

0.5 SPI + 0.5 CPI: Weighted combination of cost and schedule productivity rates experienced to date.

0.2 SPI + 0.8 CPI: Weighted combination of cost and schedule productivity rates experienced to date Used toward the end of the project.

Estimated Time to Complete (ETC). The time required to finish the project based upon the relationship between the value of the initial planned schedule and the value of the physical work performed, or SPI. ETC = Planned Completion / SPI.

Percent Complete. The ratio of the Earned Value to the budget at completion. % Complete = (BCWP / BAC) x 100.

Percent Planned. The ratio of the current plan to the budget at completion. % Planned = (BCWS / BAC) x 100.

Percent Spent. The ratio of the actual costs to the budget at completion. % Spent = (ACWP / BAC) x 100.

SPI. See Scheduled Performance Index.

Scheduled Performance Index (SPI). Represents the relationship between the value of the initial planned schedule and the value of the physical work performed, or Earned Value. SPI = BCWP / BCWS.

Schedule Variance (SV). The difference between Earned Value and the budget plan (BCWS). SV = BCWP - BCWS. Schedule variance in units of time is the difference between the BCP and BCWS on the time axis.

Schedule Variance Percent (SV%). The schedule variance as a percent of the performance baseline. SV% = (SV / BCWS) x 100.

To Complete Performance Index (TCPI). The ratio of the remaining Earned Value to the remaining costs expected. TCPI = (BAC - BCWP) / (BAC-ACWP).

Total Estimated Cost (TEC). The total estimated capital cost of the project. The TEC represents the total capital funds authorized for the project including contingency funds.

Variance at Completion (VAC). The budget at completion minus the estimate at completion. VAC = BAC - EAC.

Practice 11

Scheduling and Cost Estimating

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.

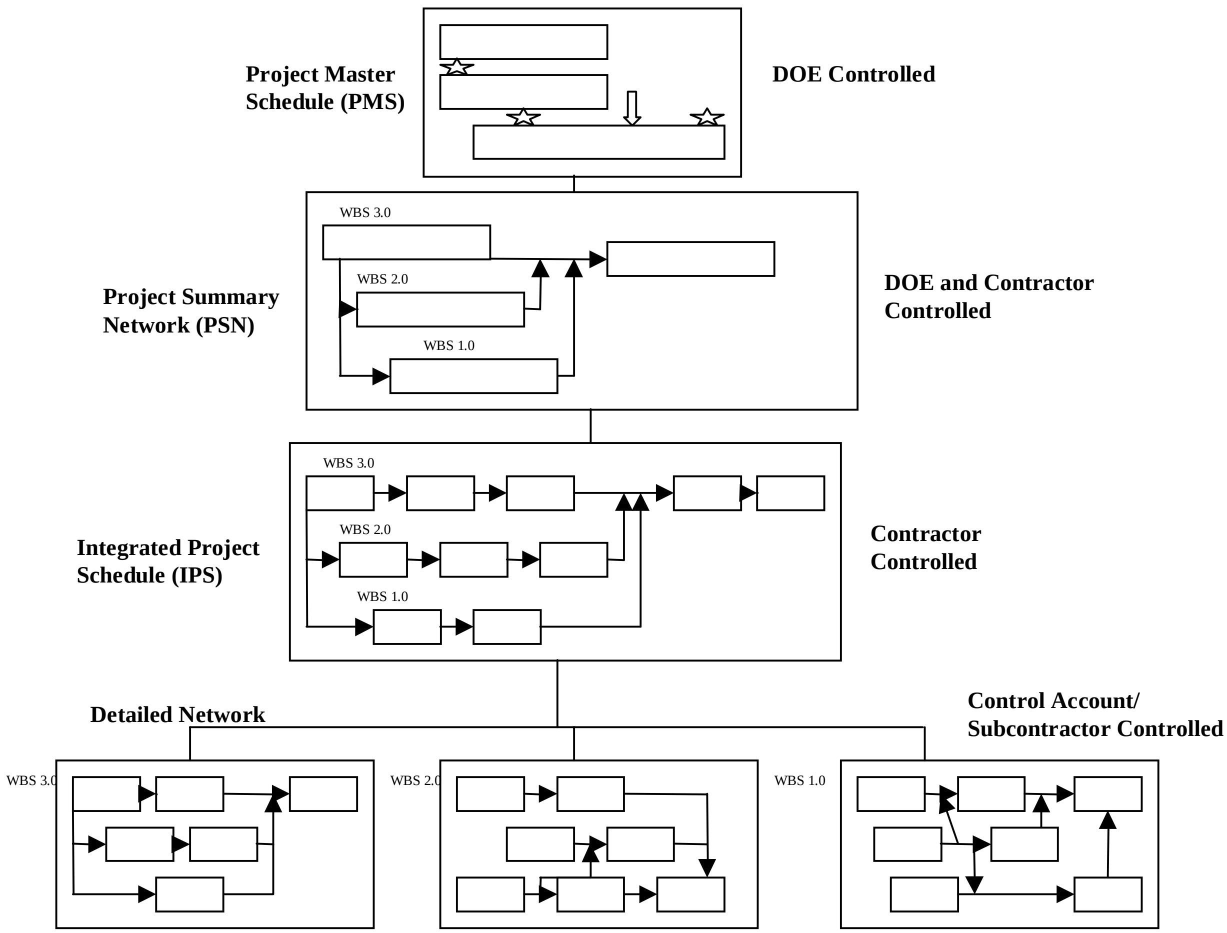


Figure 11-1. Project Schedule Hierarchy

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.

Practice 12

Contingency Management: Estimating and Allocation

12 CONTINGENCY MANAGEMENT: ESTIMATING AND ALLOCATION

12.1 OVERVIEW

Establishing an estimate for project cost is a critical factor in determining whether the subsequent execution of the project is viewed as a success or a failure. Upward revisions of a project's cost estimate invariably tend to be viewed as "cost overruns" regardless of the merits and justifications for the cost growth. In developing the cost estimate for a project, risks and uncertainties are handled by establishing appropriate contingencies within the cost estimate. Three types of contingencies are needed and used in formulating cost baselines as follows:

- DOE contingency for changes external to the contracted scope
- contingency for addressing cost uncertainties related to in-scope work
- contingency for providing the contractor management flexibility in executing in-scope work and dealing with unforseen in-scope events.

A key concept in establishing contingency is the understanding that project costs cannot be controlled (reduced) by reducing contingency. Factors that influence a project's final costs include

- actual scope executed, DOE and regulatory requirements under which the scope was executed
- resource (funding) availability in relation to the project's time-phased resource needs
- performance in scope execution

In principle, increasing the contingency does not increase project costs if the scope is controlled. The unavailability of contingency when needed by a project is likely to result in further increases in cost through schedule delays. The proper role of contingency is to provide a better forecast of expected costs at project completion and <u>not</u> project cost "control."

12.2 TPC, TEC Baseline Formulation Approaches

There are three approaches to the formulation of TPC, TEC Baselines.
See Figure 12-1.

1. *Unplanned TPC, TEC Rebaselines.* Project initiation and TPC, TEC formulations with limited contingency, but without adequate scope/design definition. During project execution, cost estimates grow necessitating one or more TPC, TEC rebaselines, the project is viewed as "out of control" with significant "cost overruns." See Figure 12-1.

2. *Planned TPC, TEC Rebaselines.* Project initiation and initial TPC, TEC formulations with limited contingency, but without adequate scope/design definition. One or more TPC, TEC rebaselines are carried out as planned during project execution as the scope/design definition evolves. Though project costs appear to be "in control," the key disadvantage is that the project's final costs were not estimated and available at the *Mission/Project Justification of Need* stage, compromising the evaluation for project approval at the project initiation phase. See Figure 12-2.

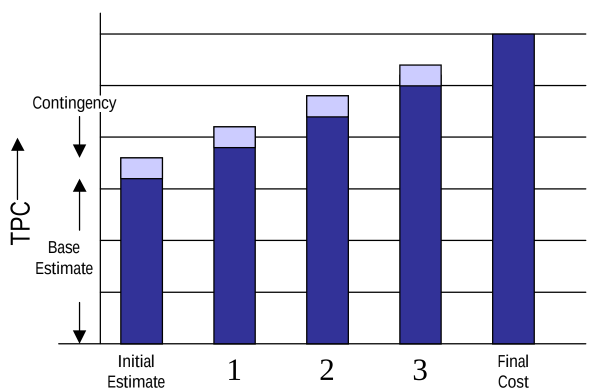


Figure 12-1. Unplanned Rebaselines

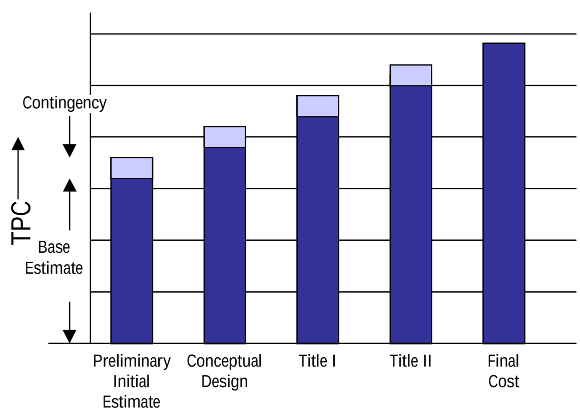


Figure 12-2. Planned Rebaselines

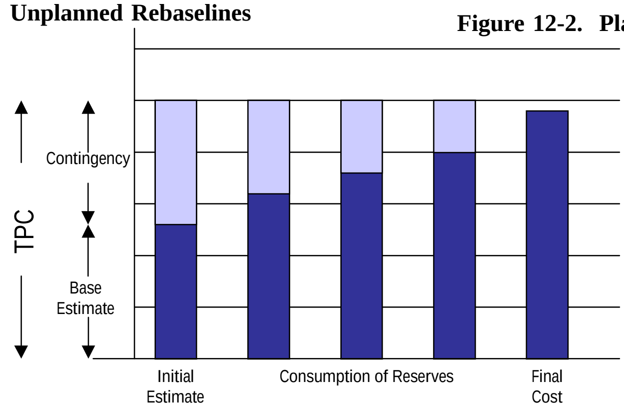


Figure 12-3. Risk Analysis-Based Formulation

3. *Risk Analysis-based TPC, TEC.* The TPC, TEC formulations based on systematic risk analysis and development, and inclusion of estimates for contingency to account for uncertainties in scope/design definition, cost estimating, DOE/Regulatory requirements, and project and programmatic risks. During project execution, the contingency transferred into budgeted scopes as needed without increasing the TPC, TEC. The key disadvantage is that contingency may constitute an unfamiliarly high percentage of the initial TPC, TEC formulations. See Figure 12-3.

This section identifies the more common factors responsible for cost growth during project execution and the methods/techniques available for estimating and managing contingency to account for these risks and uncertainties, and increasing the probability of successfully completing the project within the cost baseline.

12.3 Project Baselines and Interrelationships

In general, four different scope/cost/schedule baseline formulations are used for measuring progress/success of a project:

TPC. Total Project Cost, an estimate of expected costs at project completion including both capital and OPEX-funded costs, and provisions for scope, design, and requirements evolution/changes during project execution.

CBB. Contract Budget Baselines, representing the contractor's budget commitment for project completion encompassing the currently intended/defined and contracted project scope.

TEC. Total Estimated Cost, an estimate of construction-related capital costs limited to design/procurement/construction of facility/system including provisions for scope/design requirements evolution/changes during project execution.

PMB. Performance Measurement Baseline, an aggregation of time-phased budgets allocated to project scope elements for project execution and performance measurement.

These baseline cost (and schedule) estimates are linked to each other through estimated cost elements designated as contingency.

These formulations are applicable even when the project is entirely OPEX-funded. In relation to conventional construction projects, remediation projects may often have significantly higher uncertainties in scope definition at project inception making contingency estimates even more critical for project completions within the cost baselines.

12.3.1 Remediation Projects

For remediation projects, scope definition and the associated cost estimating uncertainties are chiefly dependent on the following two factors:

- Characterization of the facilities to be remediated.
- Definition/decisions of end-point states for the facilities to be remediated.

In some instances these two factors will evolve during the execution of the project rather than be known or definitized at project initiation. Unless adequate contingencies or TPC ranges have been established at project inception, to address these uncertainties, there is a strong likelihood that the TPC will have to be increased and rebaselined during project execution. Cost estimates developed for the EIS/ROD are conceptual and relative in relation to the alternatives being evaluated. The ROD estimate may need to be revised/adjusted for formulating a project execution baseline.

12.3.2 Total Project Cost Estimate

The Total Project Cost (TPC) is intended to be an estimate of costs at project completion, representing the cost/schedule baseline against which overall project success is frequently measured. The TPC includes both the capital and OPEX funded cost components. The capital component is limited to design/procurement/construction activities related to facility or system acquisition and referred to as total estimated cost for construction (system or facility cost). Development, engineering, and system/facility startup costs are generally OPEX-funded and referred to as other project costs (OPC). For conventional construction projects, project completion equates to turnover of the system/facility to the facility manager for operation, i.e., costs related to operation/maintenance of the facility are not generally included as part of the project costs and accordingly are excluded from the TPC. For construction projects the TEC is often a high percentage of the TPC.

In a scope execution context, the TPC can be viewed as having two components: the Contract Budget Baseline (CBB, see below) which represents the cost of the currently contracted scope of work, and DOE contingency which represents the potentially necessary additions to the contracted scope of work during project execution. These may be either additions of scope or budget increases to cover cost increases not in the contractor's control, risks and uncertainties in scope/design definition, technology development, cost estimating, DOE/regulatory requirements, or unforeseen factors.

Figure 12-4 and Figure 12-5 schematically show the decomposition elements of the TPC and their interrelationships.

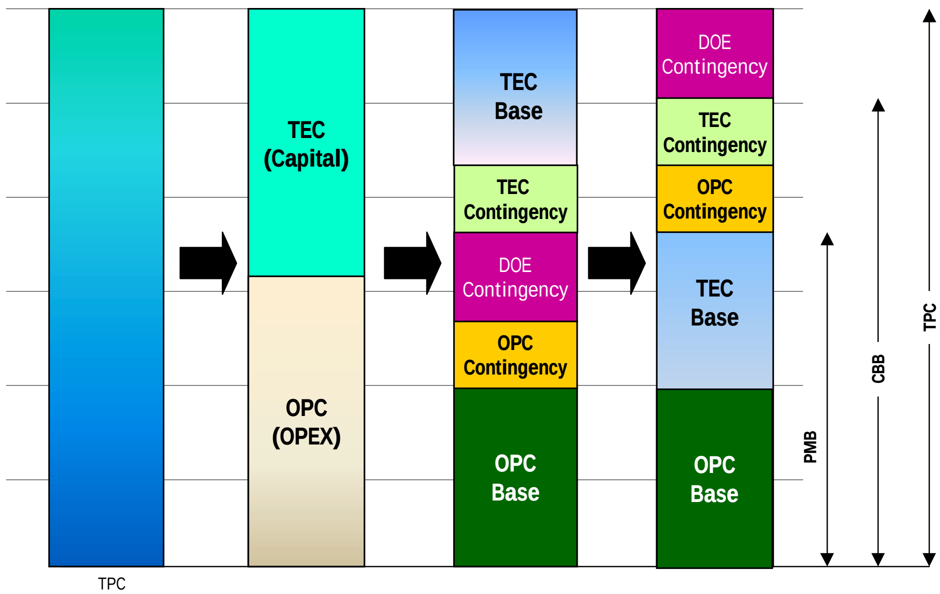


Figure 12-4. TPC Decomposition into Component Elements and their Interrelationships

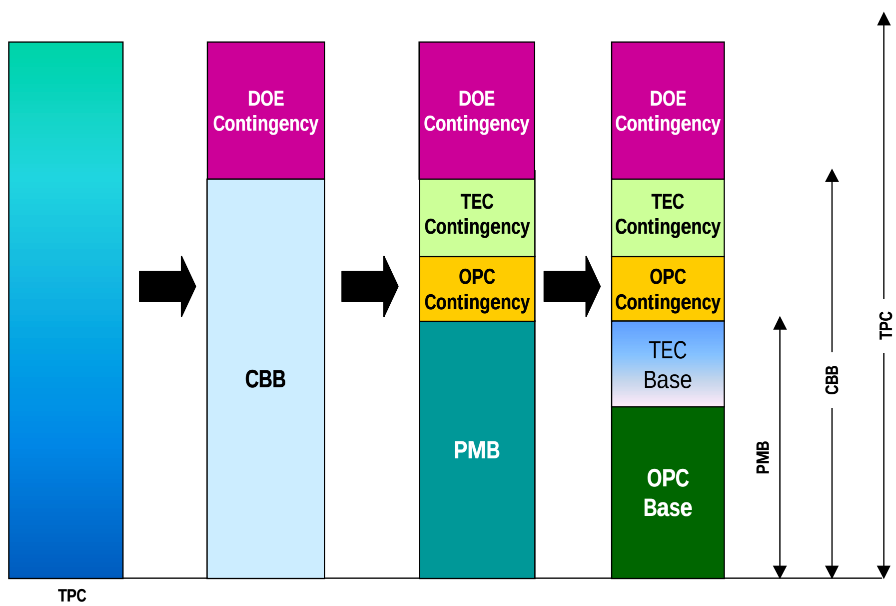


Figure 12-5. TPC Decomposition into Component Elements and their Interrelationships

During project execution, as needed, the DOE budgets are transferred via change control to the CBB for scope execution (see Figure 12-6).

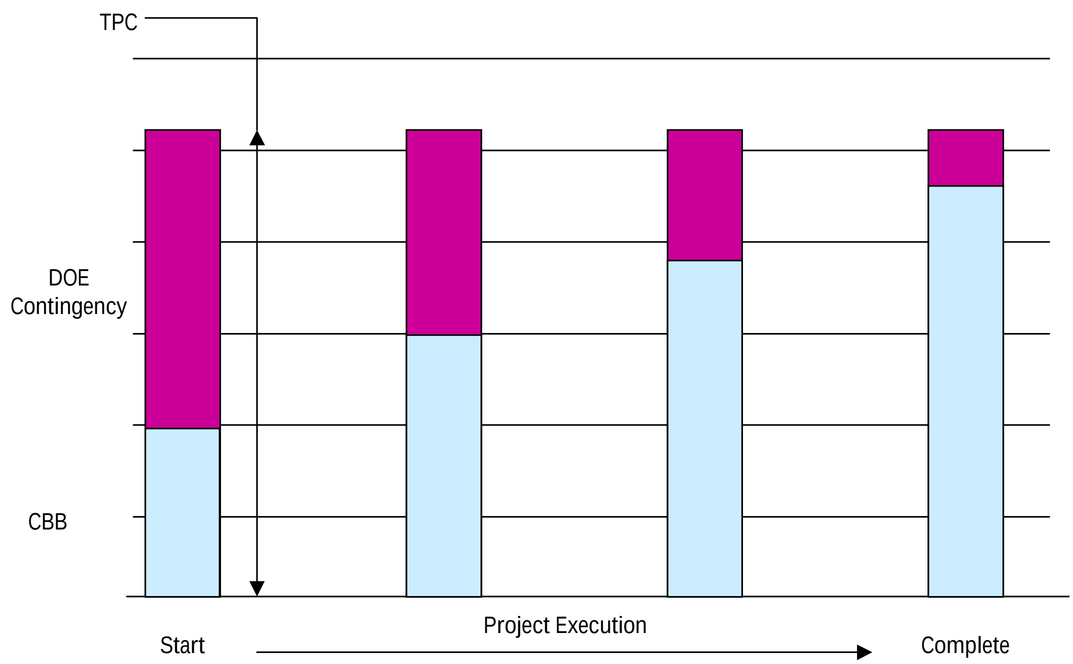


Figure 12-6. Contract Budget Baseline Growth During Project Execution: changes in scope/ requirements accommodated without increasing TPC by transferring DOE Contingency to CBB

12.3.3 Contract Budget Baseline

At any given time in the life of the project, the CBB represents the contractor's budget commitment for project completion encompassing the currently intended scope of the project. While the CBB includes TEC and OPC contingencies (Figure 12-5, and see below) to account for risks/uncertainty associated with the currently intended scope, it is not designed to accommodate additions of scope and/or requirements, or account for factors not under the contractor's control.

12.3.4 Performance Measurement Baseline (PMB)

The Perform Measurement Baseline (PMB) is an aggregation of the time-phased budgets allocated to scope elements within the currently intended and defined scope of the project. Normally, it does not include any contingency though, during the execution of the project, budget may be transferred from contingency to the PMB via documented change control (Figure 12-7). Any changes to scope/cost/ schedule for the PMB must be documented and approved via change control.

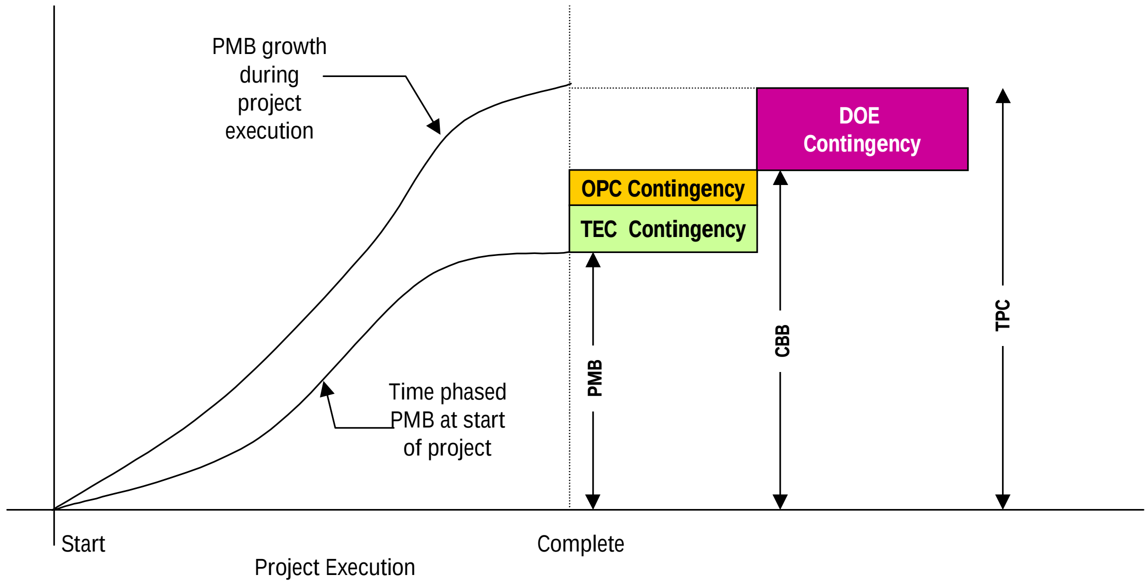


Figure 12-7. During project execution, contingency is transferred to the PMB—project completion achieved without TPC growth

12.3.5 Total Estimated Cost

The TEC, sometimes referred to as the total estimated construction cost (TECC), reflects the capital component of the total project costs (TPC). These capital costs relating to design, equipment procurement, and construction are considered to be the facility/system acquisition costs. The TEC does not include development, engineering, or startup costs which are generally OPEX-funded.

The TEC has the following two components: a base estimate, reflecting budget allocations for scope elements for the currently defined/intended scope of work, and a TEC contingency, the capital portion of contingency addressing cost estimating uncertainties associated with the hardware design/procurement/construction costs.

TEC = TEC (base) + TEC Contingency

The TEC concept is applicable even when the construction is OPEX-funded.

12.3.6 Baseline Interrelationships

TPC = CBB + DOE Contingency

TEC = TEC (base) + TEC Contingency

OPC = OPC (base) + OPC Contingency

PMB = TEC (base) + OPC (base)

CBB = PMB + TEC Contingency + OPC Contingency

Figures 12-4 through 12-8 illustrate the component elements of the TPC and the interrelationships between the various baselines and contingency.

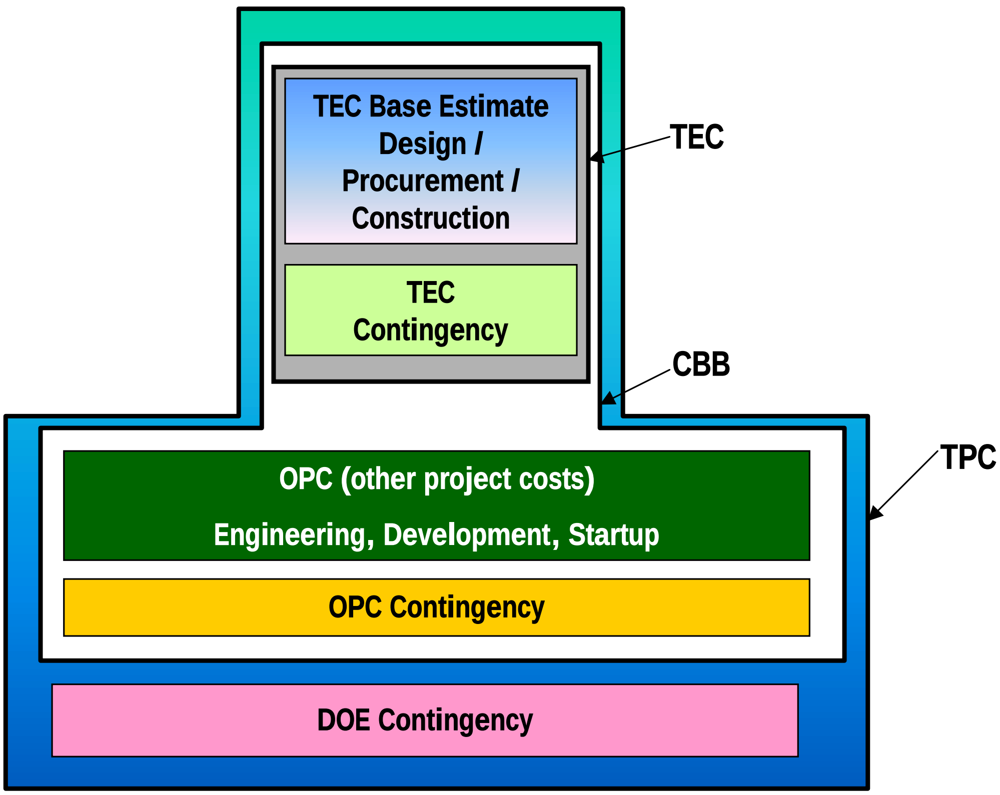


Figure 12-8. TPC Elements and their Interrelationships

The performance baseline (PB) represents the DOE commitment to Congress to assess Total Project Cost (TPC). The TPC baseline is a guide by which Congress assesses DOE performance and is a reference point for Congressional and GAO inquiries related to DOE project management performance. **Therefore, TPC baseline shall be established with a high degree of confidence so that project completion can be achieved within the cost and schedule baselines.** An element in formulating the performance baseline is a systematic risk analysis that identifies and assesses uncertainties related to project scope and design definition; and also the development and inclusion of adequate contingency to address factors that might cause cost/schedule growth during project execution. Project completion without an increase in the TPC is the primary measure of success in formulating the TPC performance baseline.

The TPC for the performance baseline shall be established at CD-2. If established earlier, it is done after careful consideration. Establishing a performance baseline earlier than CD-2 is a contributor to baseline growth. The project manager is responsible for project completion within the performance baseline.

In establishing the performance baseline, project completion shall be clearly and unambiguously defined. A primary consideration is whether project completion is defined as system/facility turnover to the user, or whether subsequent costs (operating and D&D) are included in the performance baseline (life-cycle approach).

From a Congressional accountability perspective, the Performance Baseline shall capture <u>all</u> project costs (Total Project Cost (TPC) includes both the capital and OPEX components) even if the project is fully OPEX funded. Thus,

TPC = TEC + OPC (including all contingency)

TEC is Total Estimated Cost, representing system/facility design/procurement/construction costs related to system/facility acquisition, executed with capital funds.

OPC is Other Project Costs related to engineering, development, startup, and operations. These activities/costs are essential for project execution, and are not considered a part of the normal capital system/facility acquisition costs, and are thus OPEX funded.

12.3.7 TPC Baseline and Contingency

Total project cost formulation is based on the development of the component baselines that are linked together by estimating and allocating appropriate contingency based on risk analysis.

The DOE project execution is through a Contract Budget Baseline (CBB) that represents the DOE/contractor contractual agreement for execution of the currently defined project scope of the project. Thus, while the CBB represents the project scope as presently understood/intended, the TPC includes expected project completion costs.

TPC = CBB + DOE Contingency

The DOE contingency is controlled by DOE, held outside the CBB, and transferred to the CBB as needed during project execution via documented change control. This Contingency is intended to account for evolution/changes to the project scope, and other events that occur between establishing the CBB and project completion that are beyond the control of the contractor. Simply stated, the DOE contingency should be adequate to cover all out-of-scope changes that occur during project execution. The DOE contingency should include a 3 percent to 5 percent (management decision) allowance to account for the unknown unknowns.

The CBB itself is comprised of two components:

CBB = TEC (Capital) + OPC (OPEX) (including TEC and OPC contingencies)

TPC = CBB + DOE Contingency

For both the TEC and OPC, the uncertainties related to design evolution, estimating, and changes within the contractor’s scope are addressed through establishing contingency.

TEC = TEC (base) + TEC Contingency

OPC = OPC (base) + OPC Contingency

Note that during project execution, as the TEC and OPC contingencies are utilized and become part of the TEC (base) and OPC (base), the TEC and OPC do not change. The TEC and OPC increase only when the DOE contingency is utilized through change control and transferred to the CBB.

There are two approaches to budgeting the TEC and OPC contingencies that are part of and included within the CBB:

1. Contingency is part of and included within the cost account budgets established in the Performance Measurement Baseline (PMB) for scope execution. In this case, the PMB is equal to the CBB.

2. The TEC and OPC contingencies are held outside the PMB cost account budgets and during project execution transferred to the PMB cost accounts via the change control process. Thus

PMB = TEC (base) + OPC (base)

CBB = PMB + TEC Contingency + OPC Contingency

TPC = CBB + DOE Contingency

Contingency is part of the expected costs at project completion and, therefore, must be included in the TPC established as the performance baseline. During project execution, contingency is transferred, via a documented change control systems, to the CBB and/or the Performance Measurement Baseline for scope execution. Tracking of the consumption of contingencies during project execution is part of the periodic review/update of the Risk Management Plan. This plan serves as the documented basis for developing and establishing project contingency used for formulating CBB and TPC baselines.

In summary, the TPC established as the project's performance baseline must include contingency. The three components of contingency are:

- TEC Contingency
- OPC Contingency
- DOE Contingency

The TEC and OPC contingencies are included in the Contract Budget Baseline. The DOE contingency is included in the TPC as part of the expected cost, but is held outside the CBB.

Several "baselines" have been discussed in this section including TPC, TEC, OPC, CBB and PMB. These "baselines" are linked to each other through the various contingency elements as discussed above. The baseline formulations presented here are intended to ensure the following:

1. Project execution and completion without an increase in the TPC. This is accomplished by establishing the DOE contingency as part of the TPC, which is totally controlled by the DOE, and initially held outside the Contract Budget Baseline.

2. Significant progress in project execution without any changes to the CBB, TEC or OPC baselines unless and until the DOE Contingency (controlled by the DOE) is utilized in the project.

3. Significant ability during project execution to address uncertainties and changes without increases to the TEC or OPC through transfer of the TEC contingency and OPC contingency to the Performance Measurement Baseline via documented change control.

4. Tracking and reporting of rate of consumption of each contingency allowance—TEC, OPC, DOE.

12.4 RESPONSIBILITIES

12.4.1 Federal Project Manager

The FPM is responsible for developing and establishing the TPC, TEC baselines, defining and controlling the scope of the project, and project completion within the TPC, TEC cost and schedule baseline. The FPM develops and implements the acquisition and Project Execution Plan.

12.4.2 Contractor Project Manager

The contractor project manager is responsible for executing the currently intended, defined, and contracted scope of work within the CBB in accordance with all DOE requirements, procedures, and standards. The project manager is responsible for executing the project within approved cost, schedule, and scope baselines as defined in the project execution plan.

12.4.3 Risk Identification and Analysis

An essential part of project planning is to ensure that the risks associated with the project have been identified, analyzed, and determined to be either avoidable or manageable. Risk identification and analyses should be continued through the succeeding stages, including the acquisition plan and the Project Execution Plan. Each of the identified risks is monitored at each CD to ensure that they have been satisfactorily addressed, eliminated, or managed.

The Acquisition Plan is developed by the project manager. The contractor may be consulted during development of the acquisition plan. At DOE's discretion, and when appropriate, the contractor may also participate in the development of the Project Execution Plan which is an agreement on project planning, management and objectives between the Headquarters program office and the field. The Project Execution Plan shall include the following elements:

- Project cost, schedule, and scope baselines (including separately identified contingencies)
- Risk management plan

12.5 TYPES OF CONTINGENCIES

12.5.1 DOE Contingency

The DOE contingency is the part of the expected cost estimate established outside the CBB, but inside the TPC, to account for scope evolution/definition changes and changes in requirements. During project executions, this contingency is transferred to the CBB via documented change control to reflect scope additions/ changes to the CBB without impacting the project TPC. The DOE contingency has both Capital and OPEX funding components.

Factors that influence the amount estimated for DOE contingency within the TPC include the following:

- *Confidence Level.* The greater the desired confidence level for project completion within the TPC, the higher the allocation of DOE contingency. This approach would require utilization of probabilistic and statistical techniques including Range estimating and Monte Carlo simulations (Figure 12-9).

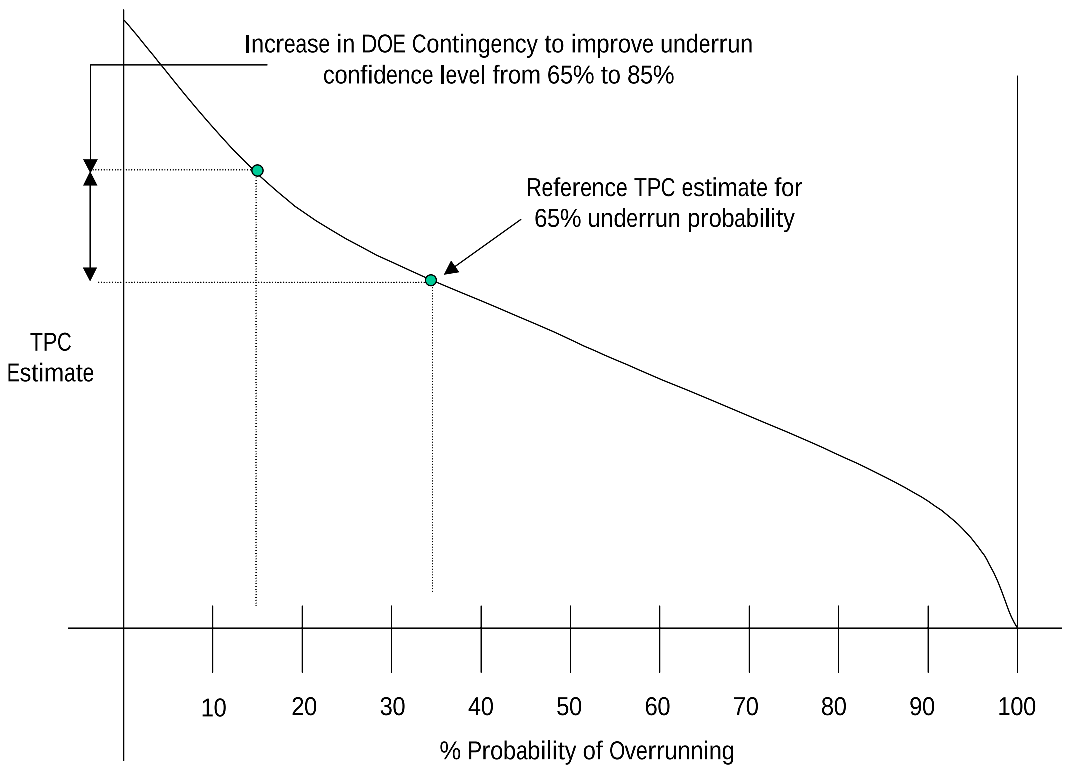


Figure 12-9. Monte Carlo Simulation: Estimating and Allocating Contingency

- *Nature of Project.* First-of-a-kind projects, that have a significant level of development effort that include new processes and technologies, have greater uncertainties in definition of requirements and scope definition, requiring higher level of DOE contingency. These projects would require use of probability-based estimating techniques and Monte Carlo simulations to envelope the uncertainties associated with developmental work, lack of prior experience, and inexact scope definition. On the other hand, projects that are similar in nature to projects executed in the past (experience) would require lower levels of DOE contingency.

- *Project Scope and Requirements Definition.* The better defined the project scope, requirements are, the lower the potential for significant scope changes during project execution. Thus, scope definition at the initiation stage of a first-of-a-kind project involving technology development would have a greater uncertainty than a conventional construction project supported by extensive prior experience. As a result, a TPC developed for a first-of-a-kind project (greater scope definition uncertainty) would have a higher share of DOE contingency than a TPC for a conventional construction project (for equal TPCs).

  Scopes that are essential to a project, but not defined well enough to be included in the CBB, may be estimated and held in the DOE contingency for subsequent transfer of scope/budget to the CBB.

12.5.2 TEC and OPC Contingency

The TEC contingency accounts for cost-estimating uncertainties associated with the hardware design/procurement/construction costs. The uncertainty is primarily associated with the degree of scope definition, the project functional requirements, and the level of design definition. Thus, at the conceptual design stage, facility, equipment, and footprint requirements are less well defined than at final design stage. The DOE cost-estimating handbooks and guides associate percent contingency with level of design definition, and nature of equipment/facility (e.g., first-of-a-kind, nuclear). Contingency is estimated at both elemental design level and in an overall sense. TEC contingency is considered a part of the TEC and is not intended to accommodate changes/additions of scope or accommodate events outside the contractor's control. TEC contingency is held outside the Performance Measurement Baseline (PMB). All transactions to and from the TEC contingency are documented via change control.

Similar considerations apply to project cost elements that are not a part of the TEC and designated as OPC. OPC contingency is treated the same way as TEC contingency.

During the course of the project, contingency is expected to transfer to the base budget within the PMB via change control and be expended.

Contingency is an integral part of the expected costs of a project. Definitions of contingency include the following:

- Specific provision for unforeseeable elements of cost within ***the defined project scope.*** Contingency is particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events that will increase costs are likely to occur

- Covers costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of contingency will depend on the status of design, procurement, and construction, and the complexity and uncertainties of the component parts of the project. Contingency is not to be used to avoid making an accurate assessment of expected cost.

A written contingency analysis and estimate should be performed on all cost estimates and maintained in the estimate documentation file.

The ranges provided in the DOE cost-estimating guide can be used for estimating contingency for small projects. However, larger projects require a more detailed analysis including a cost-estimate basis and a written description for each contingency allowance assigned to the various parts of the estimate. For large projects with significant uncertainties, a probability based risk analysis (e.g., using Monte Carlo simulations) should be used for estimating contingency.

Table 12-1. Contingency Allowance Guide by Type of Estimate

	Type of Estimate	Overall Contingency Allowances % of Remaining Costs Not Incurred
1	PLANNING (Prior to CDR) Standard Experimental/Special Conditions	 20% to 30% Up to 50%
2	BUDGET (Based upon CDR) Standard Experimental/Special Conditions	 15% to 25% Up to 40%
3	PRELIMINARY Design	10% to 20%
4	FINAL Design	5% to 15%
5	GOVERNMENT (BID CHECK)	5% to 15% Adjusted to suit market conditions
6	CURRENT WORKING ESTIMATES	See Table 11-2
7	INDEPENDENT ESTIMATE	To suit status of project and estimator's judgement

Justification must be documented in writing when guide ranges for contingency are not followed. If extraordinary conditions exist that require larger contingencies, the rationale and basis should be documented in the estimate.

Estimate types 1 through 5 in Table 12-1 are primarily an indication of the degree of completeness of the design. Type 6, current working estimates, found in Table 12-2, depends upon the status/progress of design, procurement, and construction activities (elements). Contingency is calculated on the basis of remaining costs not incurred. Type 7, the Independent Estimate, may occur at anytime, and the corresponding contingency would be used (e.g., 1, 2, etc.).

TABLE 12-2. Contingency Allowances for Current Working Estimates

		Item Contingency on Remaining Cost Not Incurred
a. ENGINEERING	Before Detailed Estimates:	15% to 25%
	After Detailed Estimates:	10%
b. EQUIPMENT PROCUREMENT		
	Before Bid:	
	Budget	
	Title I	15% to 25%
	Title II	10% to 20%
	After Award:	5% to 15%
	Cost Plus Award Fee (CPAF) Contract	15%
	Fixed-Price Contract	1% to 5%
	After Delivery to Site (if no rework)	0%
c. CONSTRUCTION		
	Prior to Award:	
	Budget	15% to 25%
	Preliminary Design	10% to 20%
	Final Design	5% to 15%
	After Award:	15% to 17-1/2%
	CPAF Contract	15% to 17-1/2%
	Fixed-Price Contract	3% to 8%
d. TOTAL CONTINGENCY (CALCULATED)		

12.5.3 Conventional Construction Projects

Table 12-1 presents the contingency allowances by type of construction estimate for the seven standard DOE estimates. Table 12-2 presents the guidelines for the major components of a construction project.

Factors that need to be considered in calculating contingency for specific elements in the estimate include: state-of-the-art design, required reliability, equipment complexity, construction restraints due to continuity of operation, security, contamination, environmental (weather, terrain, location), scheduling, and other items unique to the project, such as nuclear and waste management permits and reviews. Contingency ranges for these elements are 5% to 50%.

12.5.4 Design Completeness or Status

Design definition at the conceptual design phase would have a greater uncertainty than at the detailed design phase. Thus a contingency estimate developed at conceptual design would be a higher percentage share of the TEC than at the detailed design phase for equivalent TEC scopes (Figure 12-10).

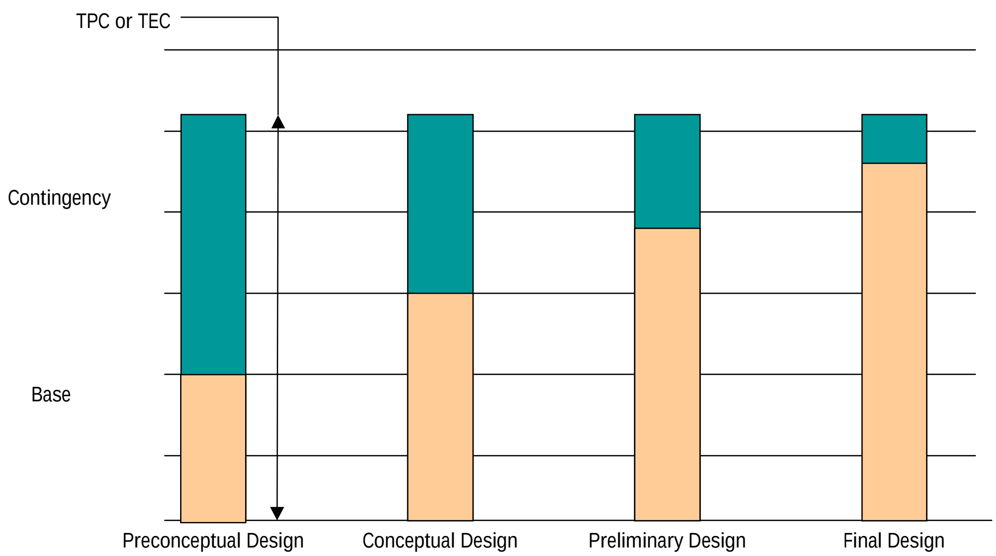


Figure 12-10. Higher Percent Allowance Needed for Contingency Depending on Degree of Lack of Design Definition

The degree of detailed design to support the estimate is the primary factor. This is the major reason that the ranges in Table 12.2 vary from 20 to 30 percent in the planning estimate to 5 to 15 percent at the completion of detailed design. Different elements of the estimate may have different degrees of design completion, and the appropriate contingency percent should be used.

12.5.5 Market Conditions

Market condition considerations are an addition or a subtraction from a project cost that can be accounted for in contingency. The closer the estimated element is to a firm quoted price for equipment or construction the less the contingency, until reaching 1 to 5 percent for the current working-type estimate for fixed-price procurement contracts, 3 to 8 percent for fixed-price construction contracts; and 15 to 17.5 percent for cost-plus contracts that have been awarded. Higher contingency percentages would be used if significant "change notices" are expected/ planned.

12.5.6 Special Conditions

When a technology has not been selected or developed for a project, an optimistic-pessimistic analysis can be completed. For each competing technology, an estimate is made. The difference in the estimates of the optimistic and pessimistic alternative can be used as the contingency. Alternatively, a probabilistic approach (Monte Carlo simulation) may be utilized.

12.5.7 Environmental Restoration Projects

Environmental restoration projects usually consist of an assessment phase and a remediation/cleanup phase. Contingency plays a major role in the cost estimates for both phases. Recommended contingency guidelines for each phase are shown in Table 12-3.

TABLE 12-3. Contingency Guidelines for Environmental Restoration Projects

Activity and Estimate Type	Expected Contingency Range
Preliminary Assessment/Site Investigation Planning Estimate for All Assessment Activities	Up to 100%
Preliminary Estimate for All Assessment Activities	30% to 70%
Remedial Investigation/Feasibility Study Detailed Estimate for All Assessment Activities	15% to 55%
Planning Estimate for All Cleanup Phase Activities	20% to 100%
Contingency Guidelines for Remediation/Cleanup Phase	
Pre-Design Preliminary Estimate for All Remediation/Cleanup Phase Activities	Up to 50%
Remedial Design and Action Detailed Estimate for All Remediation/Cleanup Phase Activities	0% to 25%

- *Assessment Phase.* An assessment determines and evaluates the threat presented and evaluates proposed remedies. As a result, the assessment encompasses such items as field investigations, data analysis, screening and evaluation studies, and the production of reports. Unlike the remediation phase, the assessment phase does not include the physical construction of a remedy. Since the assessment is one of the initial stages of the environmental restoration process, there is a high degree of uncertainty regarding the technical characteristics, legal circumstances, and level of community concern. As a result, the scope of the assessment often evolves into additional operable units and increased sampling and data evaluation. More than one assessment may be required.

  The degree of project definition will depend on how well the scope of the assessment is defined. Higher levels of project definition will correspond to increasing levels of work completed on the assessment.

  Other considerations that affect the contingency ranges include:

  — Number of alternatives screened and evaluated

  — Level and extent of sampling analysis and data evaluation

  — Technical and physical characteristics of a site

  — Level of planning required.

  Table 12-3 shows the estimate types for the assessment phase of an environmental restoration project and their corresponding expected contingency ranges.

  These are only general guidelines based on the level of project definition. A higher or lower contingency may be appropriate depending on the level of project complexity, technical innovation, market innovation, and public acceptance.

- *Remediation/Cleanup Phase.* For the remediation/cleanup phase, contingency factors are applied to the remaining design work. The contingency percentage will depend upon the degree of uncertainty associated with the project, particularly the degree of uncertainty in the scheduled completion dates.

  Table 12-3 shows the estimate types for the remediation/cleanup phase and their corresponding contingency ranges. While the ranges are relatively broad, they reflect the amount of contingency that would have been needed for a set of completed projects. The wide variance accounts for differences in project definition when the estimate was generated, project complexity, technical innovation, and other factors.

12.5.8 Monte Carlo Analyses Methodology

Monte Carlo or risk analysis may be used when establishing a baseline or baseline change for any major construction or remediation project. Monte Carlo analyses and other risk assessment techniques use similar methodology to obtain contingency estimates. A sample is illustrated in Table 12-4. The estimator and project team subdivide the estimate into separate phases or tasks and use their judgement to assess probability that the cost will fall within the specified range along with an assumed distribution.

Table 12-4 : Sample Monte Carlo Risk Assessment Methodology

Task 1		$1,000,000	Fixed Price
Task 2	40% 40% 20%	$100,000 to $250,000 $250,000 to $500,000 $500,000 to $600,000	Step-Rectangular Distribution
Task 3	50% 20% 30%	Less than $100,000 $100,000 to $200,000 $200,000 to $220,000	Discrete Distribution
Task 4	Normal Distribution	Mean = $235,000 Standard Deviation = $25,000	Normal Distribution

The distribution of the ranges is based on the estimator's judgement. For example, Task 1 is a fixed price of $1,000,000 with no anticipated change orders. For Task 2 there is a 40 percent chance the cost will be between $100,000 and $250,000, a 40 percent chance the cost will be between $250,000 and $500,000, and a 20 percent chance it will be between $500,000 and $600,000. A step-rectangular distribution was chosen.

A computer program is utilized (1000 or more iterations) to calculate the mean cost as a base estimate. With the base estimate, there is a 50 percent probability that the project will be underrun. The results in Table 12-5 show the contingency that should be used to achieve various probabilities of cost overrun. For example, a contingency of 11.1 percent should be used to achieve an 85 percent probability of project cost underrun. Therefore, the total cost estimate would be $1,902,000. If the worst case cost of each variable had been used, the total estimate would be $2,078,000, or 21.4 percent contingency.

Table 12-5: Sample Monte Carlo Simulation Methodology

Probability of Underrun	Estimate $K	Contingency (Estimate-Base) $K	Contingency % of Base
.50	1,712*	0	0
.60	1,745	33	1.9
.70	1,823	111	6.5
.80	1,875	163	9.5
.85	1,902	190	11.1
.90	1,937	225	13.1
.95	1,991	279	16.3
1.00	2,078	366	21.4

* $1,712K @ 50% underrun probability established as base estimate
$2,078 @ 100% underrun probability equates to summation of worst case costs
13.1% contingency ($225K) provides 90% confidence level.

12.6 FUNDING CONSIDERATIONS

12.6.1 Funding Profile

The cost/schedule formulations of the TEC and/or TPC baselines are predicated upon assumptions regarding the funding profile for the schedule duration of the project, constituting a de-facto baseline funding profile. Funding appropriations (current FY) and Budget Formulations (FY +1 and FY +2) at levels below the baseline funding profile can only be accommodated by scope deletions and/or scope deferrals to the outyears, thereby increasing project duration and hence the TEC and/or TPC (see Figure 12-11). The impacts of these reduced budget formulations should be documented and reported as TEC/TPC forecasts. A chart documenting baseline versus actual funding should be maintained and reported.

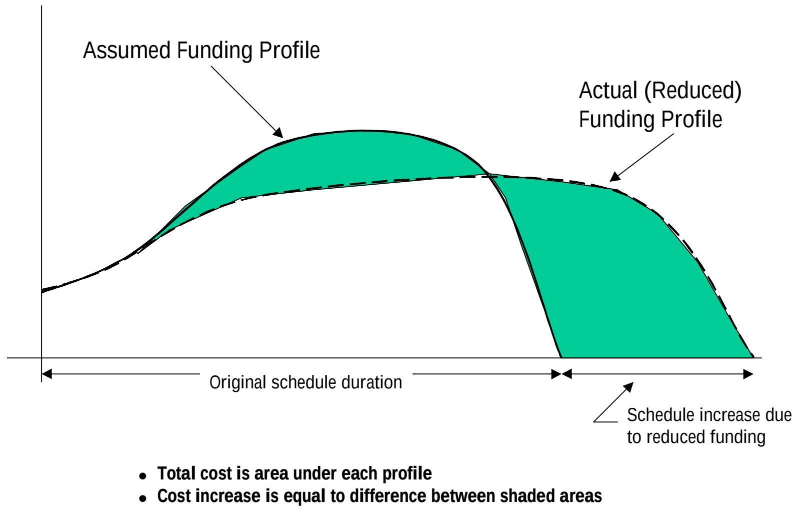


Figure 12-11. Impact of Reduced Funding

Funding profiles for Capital Funded Projects with multi-year Budget Authority loosely follow the expected expenditure profile (Figure 12-12). In contrast, for OPEX-funded projects with budget authority one fiscal year at a time, for the same schedule, the funding profile would have to be based on the expected "funds commitment" profile (Figure 12-13). This would result in a front-loaded funding profile with significantly larger year end uncosted balances. A more stable OPEX funding profile would require resequencing and rescheduling of the multi-year contracts thereby increasing project duration and total project costs (see Figure 12-14).

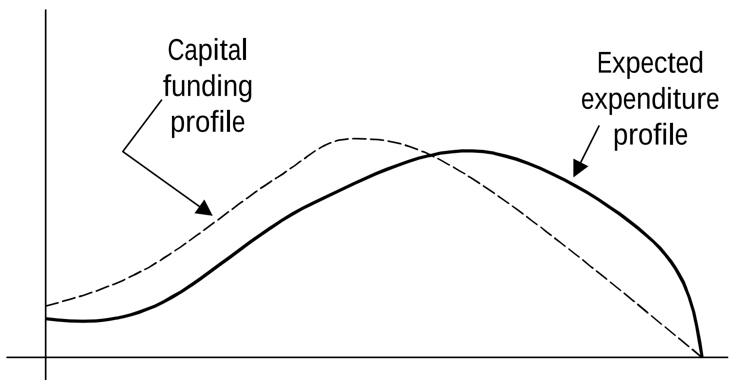


Figure 12-12. Capital Funding Profile Matches Expected Expenditure Profile

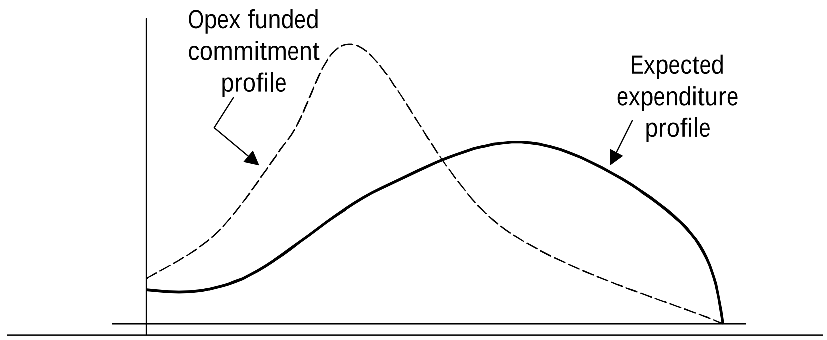


Figure 12-13. Front-loaded OPEX Profile (need for entering commitments) for same Expenditure Profile

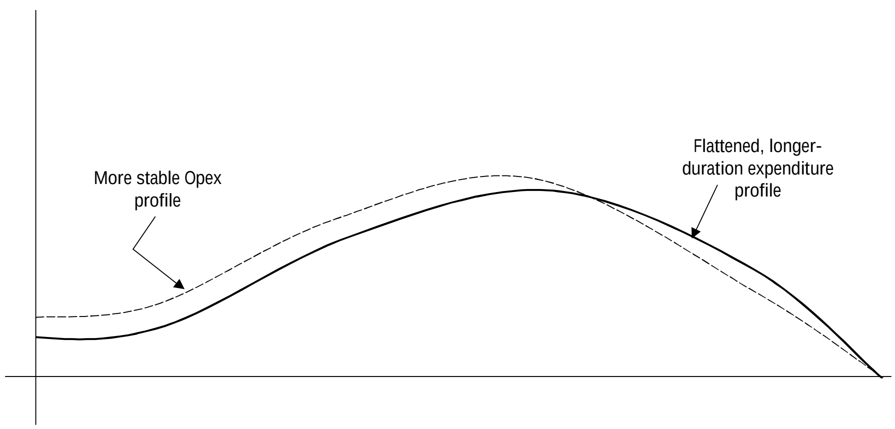


Figure 12-14. Project duration and Costs Increase when Front-loaded Commitment Profile not Supported

12.6.2 Capital vs. OPEX Funding

Capital funding with multiple fiscal year budget authority acknowledges and provides for the need by the contractor to enter into multiple fiscal year contractual commitments for design, GFE procurement, and construction activities. Planning and execution of these multi-fiscal year contracts becomes a significantly greater challenge in the OPEX funding environment which is based on fiscal year appropriation and annual budget authority. For these multiple fiscal year contracts, compliance with federal anti-deficiency statues requires significantly higher levels of "committed, but unspent" (carryover) funds at the end of any given fiscal year. The project manager must plan appropriately and adequately to protect these fiscal year end uncosted balances.

12.6.3 Flat Funding

A project schedule optimized to lowest total project cost is likely to exhibit an asymmetrical bell curve for resource needs over time (see Figure 12-15). A schedule that is constrained by flat funding resource availability will require a longer project duration resulting in increased project costs. If the TPC/TEC formulations are based on a schedule requiring a resource need (funding) profile judged to be at risk, the baseline formulations must include adequate resources for schedule extension and resultant cost increases.

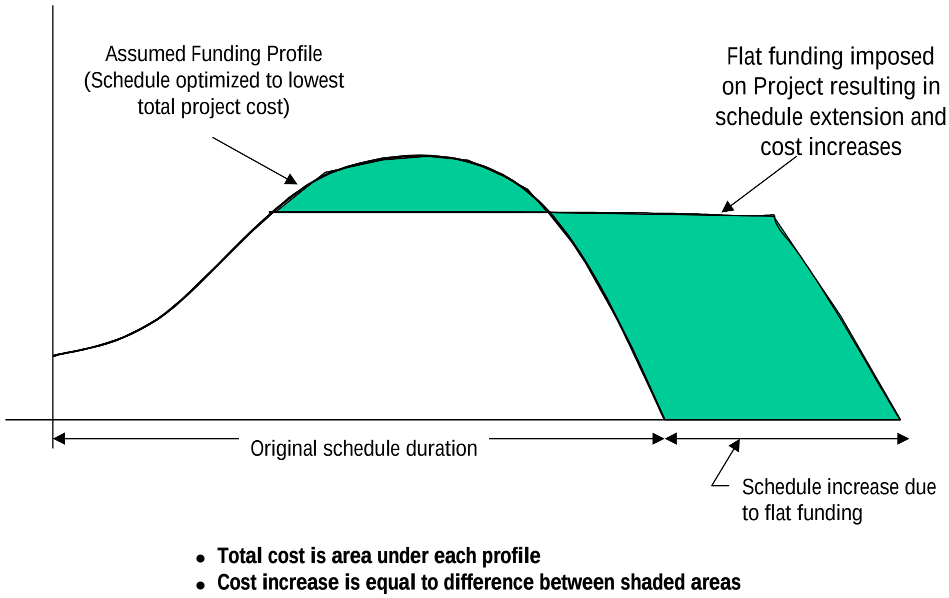


Figure 12-15. Impact of Flat Funding

12.7 Project Scope Structure

Conventional construction projects are likely to have the design/GFE procurement/ construction costs (i.e., the TEC or capital component of cost) as a high percentage of the TPC. First-of-a-kind projects are likely to require significantly higher engineering and development costs (non-TEC, other project costs) making the TEC a smaller percentage of the TPC. Furthermore, if a project is defined to include a greater share of what would otherwise be considered operating costs or site support costs, the TEC as a percentage of the TPC is reduce even further.

12.8 Project Cost Structure

The TPC for any given project is directly linked to the planned duration of the project. However, the sensitivity of the TPC in relation to project duration is strongly dependent on the project cost structure. In this context, project cost may conceptually be divided into two components:

- Fixed annual costs, totally dependent on project duration
- Fixed scope cost, variable annual cost dependent on funding.

Fixed annual costs may be viewed as annual costs incurred as part of the “cost of doing business” or a baseload annual cost, relatively fixed, that will be incurred for the duration of the project. Fixed scope variable annual costs represent, for example, $60M in GFE procurements that can be executed in 4 years at $15M/year or 5 years at $12M/year, depending on funding.

In conventional construction projects, the fixed annual cost may be only 10% to 15% of the total cost, making the total cost less sensitive to schedule delays that increase project duration. In other cases, e.g., first-of-a-kind or some remediation projects, the fixed annual costs may be significantly higher (40% to 60%). In these cases the total cost is much more sensitive to increases in project duration resulting from funding reductions, scope additions, or poor schedule performance.

Figure 12-16 illustrates an approach for determining TPC sensitivity to schedule extensions in relation to the project’s cost structure. Projects A and B both have four-year durations and TPCs of $200M. Project A has fixed annual costs of $20M /year, $80M total for four years. Project B has fixed annual costs of $5M/year, $20M total . If, for the same fixed scope costs, the durations are increased to five years, Project A’s TPC increases to $220M (a 10% increase) while Project B’s TPC increases to $205M (a 2.5% increase). Project A will require significantly higher allowances to account for schedule extension risks than Project B.

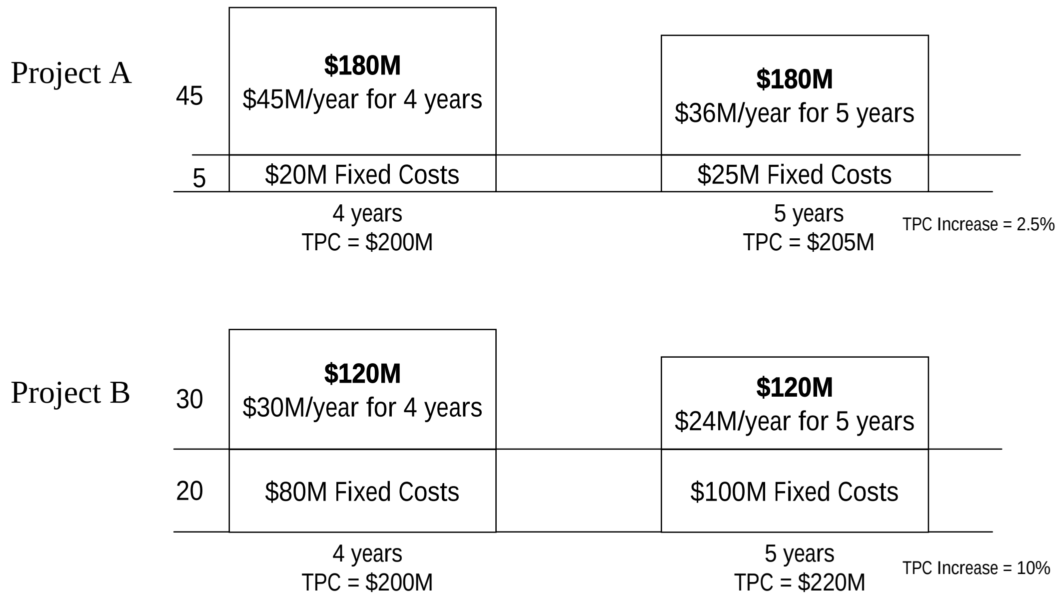


Figure 12-16. Project Cost Structure

12.9 Estimating and Allocating Contingency

The risk based approach to estimating contingency to account for the cost estimating uncertainties inherent in formulating a TPC baseline utilizes Monte Carlo simulation techniques. These techniques establish an 85% to 90% underrun confidence level for the TPC (see Figure 12-17). The probability and cost distributions assigned to the Monte Carlo simulation elements must account for all the uncertainties, including the degree of scope and design definition, maturity of technology versus first-of-a-kind efforts, project cost structure and funding profile assumptions, and potential cost impacts due to scheduling uncertainties. If all these uncertainties are not captured in the Monte Carlo simulation elements, then the 85% to 90% "confidence" level is likely to provide a false and misleading sense of security. The Federal project manager is responsible for selecting the confidence level and for project completion within the resulting TPC.

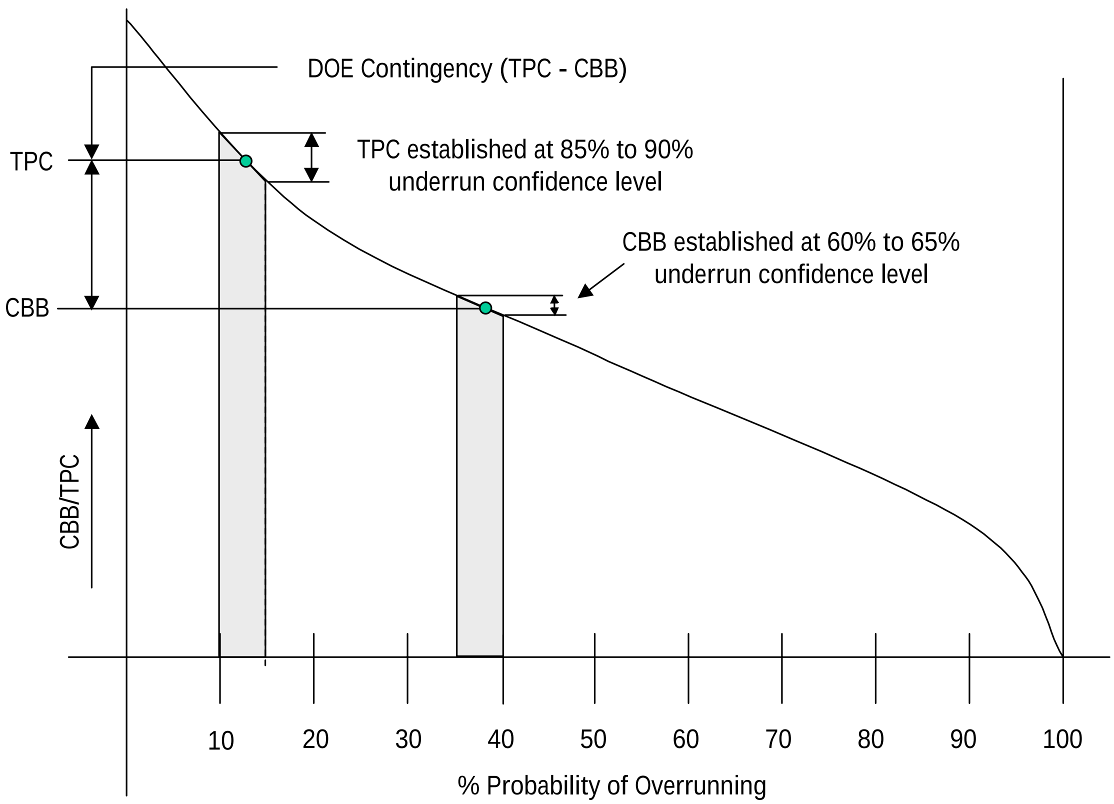


Figure 12-17. Monte Carlo Simulation: Estimating and Allocating Contingency

The "allocation" of contingency utilizing this approach establishes the project's contract budget baseline at the 60% to 65% underrun confidence level at the start of the project. During project execution, the DOE contingency is transferred to the CBB via documented change control in response to events/changes that are not within the contractor's control.

The Contractor Project Manager is responsible for execution of the defined scope within the contract budget baseline.

The assumptions used in the Monte Carlo simulation and the confidence levels used to establish the TPC and CBB baselines must be documented in the Project Execution Plan. During project execution, the risk analysis basis should be periodically reviewed and revised.

12.10 Change Control and Reporting

Change control is vital to project cost control and must be well organized and functioning. A few change control guidelines include:

- A formal change control procedure must be established that defines and documents the process for changes and control of the scope/cost/schedule baselines.
- Change control thresholds and the required levels of approvals should be tailored to the needs of the project.
- Within the Contract Budget Baseline, the contractor establishes the change control thresholds and approval levels.
- Changes to the Contract Budget Baseline and/or the TPC baseline require DOE approval.
- All changes to any element of the scope/cost/schedule baselines must be documented and maintained.
- The TPC, CBB, PMB, and TEC constitute the project's upper level baselines. Changes to these baselines must be reported in monthly and quarterly reports.
- If the TEC and/or TPC baselines have been impacted (i.e., due to funding short falls or scope changes), a forecast incorporating the impact must be reported while awaiting approval to revise the baseline.
- The rate at which the contingency is being consumed during project execution should be monitored, evaluated, and reported periodically to assess whether the remaining contingency is adequate for project completion.

12.11 Budgeting of Contingency

Contingency should be budgeted each fiscal year for each applicable Budgeting and Reporting (B&R) code for each project.

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Practice 13

Project Configuration Management

PROJECT CONFIGURATION MANAGEMENT

13 PROJECT CONFIGURATION MANAGEMENT

13.1 OVERVIEW

Successful accomplishment of a project requires that all participants be provided accurate information on the project and its end product(s) during any point in the project life cycle. As a project proceeds through its life cycle, the number of participants grows significantly and the volume of information grows exponentially. The task of managing this information is a major challenge and essential to project success.

In the early stages of a project's life cycle, the end product(s) are defined by functions and requirements contained in mission need and conceptual design documentation.

As the project progresses through the its cycle, functions and requirements are expanded to develop design requirements for functional and physical configuration of the end product(s). These design requirements, in turn, are expanded to the detail required to construct, operate, and maintain the end product(s).

Configuration management helps to ensure an orderly process for the control of changes to those products as they evolve through each project phase. Product configuration may be verified at any stage of the process that enables management decisions to be made on current information. Proposed changes may be better evaluated for impacts. Data retrieval is faster and project personnel are more confident in that data, enabling faster, more cost-effective control practices. Historical data should be more readily available, which should result in more accurate estimates on the current project as well as on future projects that may use the data.

The activities that constitute the configuration management discipline include:

- Planning and Management
- Configuration Identification
- Change Management

- Status Accounting
- Audit

13.2 Purpose

Configuration management is used to ensure and document that all facilities, structures, systems, subsystems, and components, as well as supporting documentation of a project, interface physically and functionally. This process must also ensure that the configuration is in agreement with the performance objectives in the technical baseline. Configuration management is a critical component of the Integrated Safety Management System and the maintenance program. The project manager must initiate a configuration management system early in the development of the project and must assure the delivery of as-built documents at the close of the project. Configuration management control begins with baselining of requirements documentation and ends with decommissioning of equipment in the operational facility.

Configuration management principles are used in each project phase to some degree. These principles are to be tailored to fit the phase as well as the product application to an appropriate degree as determined by project team personnel.

13.3 Configuration Management Application

13.3.1 Scope

The configuration management discipline shall be applied to all project hardware, software, firmware, documentation, test and support equipment, facility space, spares, training, and manuals. A change control system shall ensure that documentation associated with an approved change to a project's configured system is updated to reflect the appropriate baseline. Affected documentation may include training materials, courseware, and other integrated logistic support documentation.

13.3.2 Configuration Management and Baseline Management

Within DOE, the terms "baseline management" and "configuration management" have been used with some degree of confusion. The purpose of this section is to clarify the relationship.

Configuration Management—at any point in its life cycle, from planning to completion of the execution phase, a project has a configuration. Initially, its configuration is a conceptual arrangement of the parts or elements of the desired end product(s). As the project proceeds through its life cycle, the configuration is defined in greater detail through the design process and documented in specifications and drawings. At the end of the life cycle the configuration is the actual physical and functional configuration of the end product(s) as reflected in as-built documents. Configuration management is used to identify and document the configuration of the end product(s) and control changes to the configuration during the life cycle.

Baseline Management—at selected points in a project's life cycle, the current configuration is established as a reference point or technical baseline. The technical baseline is combined with other project activities (e.g., activities to construct or activities to conduct remedial action) to form a scope baseline. The scope, schedule, and cost baselines serve as a basis for project authorization, management, and an approved basis for measurement during project performance. As such, the scope, schedule, and cost baselines are the established plan or performance baseline against which the status of resources and the progress of a project are measured. Baseline management is used to measure progress and control baseline changes.

Configuration management and baseline management are integrated in that the baselines are derived from the same configuration and they often share a common change control process.

13.3.3 Configuration Management Processes

All projects shall perform to the planning, identification, change control, status accounting, and verification and audit activities described as follows:

1. *Configuration Management Planning and Management*
   This activity includes planning, coordinating, and managing all tasks necessary to implement configuration management principles and to conduct configuration management activities. Configuration management planning and management occurs throughout all project life-cycle phases. Documentation of the planning process and development of the configuration management plan and supporting procedures formalizes involvement and ensures continuity of configuration management practices at all levels of management. Training personnel commensurate with their roles and responsibilities is an ongoing

requirement. Periodic assessment of process performance needs to be performed to allow for improvements to the configuration management process.

2. Configuration Identification
   Projects shall identify configuration items and shall develop appropriate configuration documentation to define each configuration item. This activity includes the development of a product top-down structure that summarizes the total units and configuration documentation for the system or configured item. Identification also includes the assignment of unique identifiers, that identify units, and groups of units, in a product. Configuration identification and product information shall be maintained and readily available to all project participants. Baselined documentation shall be maintained with all necessary links to the information management system. Supporting documentation includes the numbers and other identifiers (e.g., document numbers, drawing numbers, equipment numbers) assigned to configuration items and documents, and the approved technical documents that identify and define configured items' functional and physical characteristics, such as specifications, drawings, and interface control documents and associated lists.

3. Configuration Change Control
   Projects shall implement a systematic and measurable change process that is consistent with DOE O 413.X, and shall document it in their approved Change Control Boards' charters and operating procedures. The implemented change process shall ensure proposed change are properly identified, prioritized, documented, coordinated, evaluated, and adjudicated. Approved changes shall be properly documented, implemented, verified, and tracked to ensure incorporation in all involved systems, equipment and spares.

4. Configuration Status Accounting
   Projects shall develop and maintain configuration information for their configured items or products in a systematic and disciplined manner in accordance with DOE policy and accepted configuration management process and procedures. Status accounting information includes developing and maintaining site or project configured data, and the incorporation of modification data on systems and configuration items. This configuration information must be available for use by decision-makers over the lifecycle of the project. It will also provide an audit trail of change proposals, current baselines, and historic baselines. Data availability and retrievability shall be consistent with the needs of various users.

5. Configuration Verification and Audit
   The configuration management process shall verify that a product's requirements have been met and the product design meeting those requirements has been accurately documented before a product configuration is baselined. Verification takes the form of a functional configuration audit and a physical configuration audit. The functional configuration audit provides a systematic comparison of requirements with the results of tests, analysis, or inspections. The physical configuration audit determines whether the product is consistent with its design documentation. In addition, operational systems must be periodically validated to ensure consistency between a product and its current baseline documentation. Verification of the incorporation of modifications is a critical function of this activity. This validation includes verification of facility baselines and conduct of system audits at project acceptance and turnover. Audit discrepancies will be identified, recorded, and tracked to closure.

13.3.4 Technical Baseline Identification

As discussed in Section 13.3.2, the technical baseline is combined with other project activities to form the scope baseline. The scope baseline is the basis for cost and schedule baselines. The technical baseline defines the physical and functional configuration of the project's end product(s). Baseline management controls the scope, schedule, and cost baselines, and integrates with configuration management which controls the technical baseline. Data management controls project information and the configuration of its end product(s).

The technical baseline consists of a top-down set of requirements in which all subsidiary requirements flow down from the requirements above them. Typical DOE technical baselines are defined below. For identification and reference purposes, each update to the technical baseline has been given a title corresponding to its content and/or relationship in the life cycle.

The titles of the baseline may vary for a particular program or project, and there may be fewer or more baselines. A minimum set of technical baselines would be those required to support scope, schedule, and cost baseline submittals for Critical Decisions.

Functions and Requirements Baseline. The initial baseline for a project is developed during the conceptual phase and supports the Approve Preliminary of Baseline Range Critical Decision. It establishes the functions and technical requirements of DOE programs and projects. At this early stage of a project, the configuration represented by the baseline is conceptual with nothing designed or built. The functions and requirements baseline is generally developed from the mission need and mission objectives.

Design Requirements Baseline. For complex projects, the design portion of the execution phase is often divided into preliminary design and final design. Through the preparation of preliminary planning and engineering studies, preliminary design translates the functions and requirements from the conceptual phase into preliminary drawings and outline specifications, life-cycle cost analysis, preliminary cost estimates, and schedules for project completion. Preliminary design identifies long-lead procurement items and provides analysis of risks associated with continued project development. At this stage of a project, the configuration defined by the preliminary drawings and outline specifications is represented by the design requirements baseline with the following content identified:

- Physical systems for each project or facility
- Boundaries and interfaces for each physical system
- The major components for each physical system
- The functions and requirements, performance criteria, and constraints established in the conceptual phase allocated to the respective physical systems and major components.

Configuration Baseline. This represents the output of the final design portion of the execution phase and supports CD-3, the Approve Start of Construction or Remedial Action. The functions and requirements from the conceptual phase and the design requirements from preliminary design, as applicable, are expanded to include the detail required to construct the components and systems of the end product(s). The configuration of the project is defined by the design output documents which include procurement and construction specifications, drawings, test procedures, and operating and maintenance information.

As-Built Configuration Baseline. At CD-4, Approve Start of Operations or Project Closeout (complete execution phase), the detail design documents established in the configuration baseline are used to establish the as-built configuration baseline as follows:

- All changes occurring to the configuration baseline during construction are approved and reflected in the as-built configuration baseline.

- All changes occurring to the configuration baseline during the operations phase (after system turnover) are approved and reflected in the as-built configuration baseline. This baseline exists and is maintained current throughout the operations phase.

13.3.5 Establishment of Baselines

Development of baselines for DOE programs, projects, and operating facilities should adhere to the following management concepts set forth by DOE O 430.1:

- Identification, documentation, and approval of basic requirements
- Specification of a systematic process for baseline development
- Formal identification and approval of baselines
- Specification of allowed variances from the approved baseline
- Regular reporting and assessment of status against the approved baselines
- Corrective management action (that may include baseline revision) in the event a variance exceeds a prescribed threshold.

13.3.6 Change Control Boards (CCB)

A hierarchical arrangement of relatable flow-down Change Control Boards shall be established by Headquarters, the respective field office, and the contractor to establish configuration management baselines and to approve/disapprove subsequent changes to those baselines. Each project board shall have an approved charter and operating procedures. Proposed changes to HQ's configuration management baselines must be submitted to the appropriate change control board on an agency approval change request form. Each Change Control Board shall document its approval/disapproval decisions. The number of boards and their specific charters and procedures will be tailored to the particular project. The intent shall be to maintain the vast majority of control actions at the contractor level.

Change Control Board charters and operating procedures shall be maintained to reflect the addition of new programs, the additions/deletions of configuration items, and changes to Board membership.

13.3.7 Energy Systems Acquisition Advisory Board

MS Project ESAABs

The ESAAB advises the SAE in making MS project CDs, Level-0 baseline changes, and site selections for facilities for new sites. The ESAAB meets once every two months, or at the call of the SAE.

ESAAB membership includes the SAE as chair; the Under Secretaries; the General Counsel; the Chief Financial Officer; the Director of OECM; the Assistant Secretary for Environment, Safety and Health; the Assistant Secretary for Environmental Management; the Deputy Administrator for Defense Programs; the Director for Office of Science; and the Director of Procurement and Assistance Management. The Deputy Secretary may designate other PSOs or functional staff as board members as needed.

The ESAAB Secretariat resides in OECM and provides administrative and analytical support and recommendations to ESAAB.

Other Project ESAABs

Each appropriate PSO appoints an ESAAB-equivalent board for advising on actions regarding those projects within the PSO office that are not MS projects. The PSO serves as AE for these projects and as chair of the ESAAB-equivalent board. The ESAAB-equivalent board replicates and the same functions as those performed by the corporate ESAAB. Members may be selected from within the PSO's office or from other Headquarters functions having Departmental responsibility. At least one member is from a different PSO office and is designated by the contributing PSO. OECM provides a member of each ESAAB-equivalent board for projects $100M and greater. Each PSO provides the composition of its ESAAB-equivalent board to OECM. Agendas and minutes of all ESAAB-equivalent boards are provided to OECM.

Delegated Other Project ESAABs

The PSO may delegate equivalent AE functions, including decision approvals, for those Other Projects below $100M to an SES program manager or an operations/ field office manager. For those delegated Other Projects below $20M, the Program Manager or O/FOM may further delegate equivalent AE functions to a direct reporting SES subordinate. Attachment 3 provides an overview of the allowable AE delegations. The AE so designated establishes and chairs an ESAAB-equivalent board, notifies OECM of its composition, invites OECM to all board meetings, and provides all agendas and minutes to OECM and the appropriate PSO project management support office. However, OECM is not a board member.

13.4 PROJECT CONFIGURATION MANAGEMENT POLICY

Each project shall be responsible for:

- Developing and implementing configuration management plan(s) and processes.
- Life-cycle management of products/solutions assigned to their Change Control Board.
- The inclusion of appropriate configuration management principles in all acquisition contracts.
- The timely approval/disapproval of proposed changes to configured items under their purview for the lifecycle of the items.
- Analyzing changes completely and coordinating changes that impact other configured items within the project.
- Referring proposed changes that exceed their approval authority to the next higher board.
- Establish baselines for all system that are operational or that are scheduled for operation. The baseline process begins with establishment of the system/subsystem functional baseline and concludes with the establishment and maintenance of the project baseline. Establishing and documenting site configurations and creating baseline documentation shall be included in this responsibility.
- Providing the user organization with detailed documentation describing the operational baseline at the time of commissioning. This documentation consists of the contractually agreed to as-built lists, updated to reflect the configuration at the time of commissioning, and the serialization/revision/version status of all hardware, software, and firmware. This documentation is in addition to the functional, allocated, and product configuration documentation. Providers must

also ensure that operations and field offices receive the contractually provided manuals. Documentation describing the operational baseline must be maintained as long as the system is operational.

Practice 14

14

Critical Decision Packages

14 Critical Decision Packages

14.1 Overview

Critical Decisions (CDs), Figure 14-1, are formal determinations made at specific points in a project. CDs are gates to be addressed before a project is allowed to proceed to the next phase or to commit additional resources. A comprehensive request for critical decisions requires development of five major CDs. CDs can be presented either in combination or singly. They include the following:

- CD-0, Approve Mission Need
- CD-1, Approve Preliminary Baseline Range
- CD-2, Approve Performance Baseline
- CD-3, Approve Start of Construction
- CD-4, Approve Start of Operations or Project Closeout.

These criteria should be uniformly adopted for all traditional construction projects, using project-specific factors such as complexity, project cost, risk management, and uncertainty. Criteria not appropriate to a particular project need not be addressed, after proper approval. This, however, should be noted in the mission need documentation.

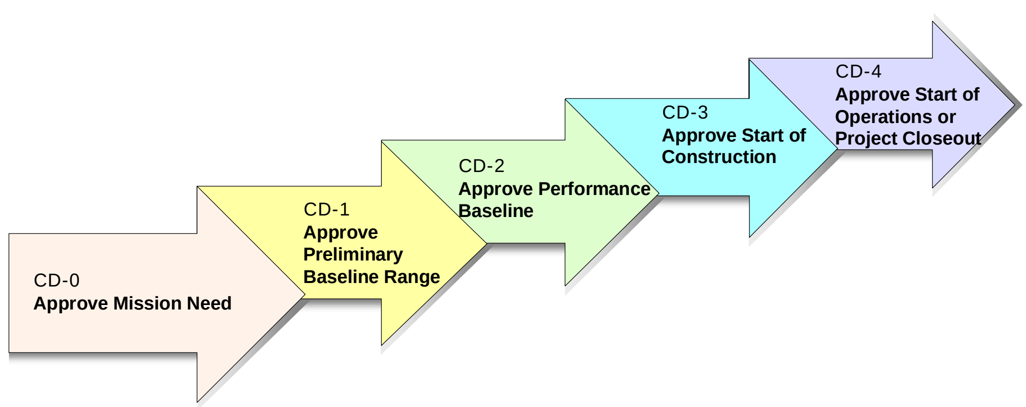

Figure 14-1. Critical Decision Flowchart

Projects other than traditional construction projects include environmental restoration, facility disposition, and privatization. Environmental Restoration (ER) and Facility Disposition (FD) projects are driven by the regulatory requirements in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA). Therefore, the critical decisions and thresholds for these projects may be different than those of a traditional construction project.

- ***Environmental Restoration Critical Decisions***
  - CD-0, Approve Mission Need
  - CD-1, Approve Preliminary Baseline/Proposed Work plan
  - CD-2/3, Approve Baseline/Start Field Work
  - CD-4, Project Closeout
- ***Facility Disposition (FD) Project Critical Decisions***
  - CD-0, Approve Mission Need
  - CD-1/2, Approve Performance Baseline
  - CD-3, Approve Start of Construction or Remedial Action
  - CD-4, Approve Start of Operations or Project Closeout

Because of statutory time limits, potential fines, extensive documentation requirements, and the nature of the CDs, ESAABs may not be required for all environmental restoration or facility disposition CDs at the discretion of the SAE/AE as appropriate.

- ***Privatization Project Critical Decisions***
  - CDs for privatization projects are addressed in the Acquisition Plan as these projects are driven by contractual agreements and the risk is shifted to the contractor.

Critical Decisions are a requirement throughout the planning and execution of a project and are necessary before proceeding to the next phase. Partial or phased CDs may also be proposed, depending on the complexity, duration, and needs of the project.

External Independent Review (EIR). An EIR is a review conducted by reviewers outside the DOE. OECM will select an appropriate contract to perform these reviews, excluding M&O/M&I contractors. The selection of reviewers, contract management and contact with the Contracting Officer, and dialogue with the EIR contractor on matters pertaining to the contract are the sole purview of OECM. The PSO's project management support office provides coordination for the EIR contractor on site, resolves issues of schedule and access while on site, gathers and provides requested and proffered information to the reviewers, and responds to the reviewer on errors of fact or needed clarification. The project management support office does not provide direction to the reviewer on the content of the reviewer's report.

EIRs are managed by OECM as DOE's agent. Line management, including the Deputy Secretary, PSO, or a program or project organization within the PSO, may request an EIR. EIRs also may be initiated in response to an external requirement; however, reviews, studies, or investigations conducted by the General Accounting Office or the Office of the Inspector General are not considered EIRs for DOE purposes. OECM coordinates all such reviews with the appropriate PSO to define the review scope, choose an optimal time during the acquisition process to minimize project impacts, minimize the impact on the project by conducting multiple reviews, and evaluate the credentials of potential reviewing organizations and individuals.

The following EIRs are conducted on all projects over $5M:

- Performance Baseline Validation EIR. This is a detailed review of the entire project, including and ICE, prior to CD-2. It verifies the mission need; validates the proposed technical, cost, and schedule baseline; and assesses the overall status of the project management and control system.
- Execution Readiness EIR. This is a general review of the project prior to CD-3 that may range from an abridged review of specific areas within a project to a comprehensive review of the entire project. At a minimum, it verifies the readiness of the project to proceed into construction or remedial action.
- Independent Cost Estimates (ICEs). ICEs are used to verify project cost and schedule estimates, and support the CD-2 process in establishing project performance baselines. ICEs are part of the Baseline Validation EIR, although an ICE can be combined with an EIR or IPR for efficiency. ICEs may be requested at other times and for other reasons. OECM works through appropriate contracting officers to establish contracts for ICEs. ICEs are documented in formal reports submitted to the SAE/AE by OECM. Each ICE is reconciled with the current Program Office estimate by the Federal project manager.

14.2 Requirements for Critical Decision-0

Critical Decision-0 involves the formal conceptualization of a recommended or proposed project and the preparation of an Justification of Mission Need document. This initiates the pre-project planning activities identifying the principle requirements to be met for the project's strategic goals and objectives. The sponsoring organization forwards this documentation to the DOE Program Office/DOE Field Office for review and validation.

Mandatory elements of the Critical Decision-0 documentation include

- ▸ A brief description of the proposed project, explaining integrated mission need in light of technical or other influences on the program
- ▸ Identification of work element priorities and constraints, and a discussion of the pre-project planning process
- ▸ Ensuring that risks associated with the project have been identified, analyzed, and determined to be either avoidable or manageable. This is an essential part of project pre-planning.
- ▸ Special studies, a technical data summary, a feasibility evaluation, characterization studies, and legal reviews (if required) to assure that the base document establishes a consistent and unambiguous understanding of the mission requirements and responsibilities
- ▸ Budget forecasts, financial justification, and strategies explaining any tradeoff in current scope, cost, or schedule based on very preliminary information
- ▸ Identification of project coordination interfaces up to the point of Critical Decision-0 approval and for the transition to Critical Decision-1
- ▸ Request of Project Engineering and Design (PED) funds after development of a preliminary PED document.
- ▸ Preparation of a preliminary acquisition strategy.

14.2.1 Preliminary Acquisition strategy

Acquisition development is a four part process that begins with preconceptual planning and risk identification and analysis.

- *Preconceptual Planning.* Preconceptual planning focuses on the program's strategic goals and objectives. Before a project is formally initiated, a formal consensus on project objectives, functional requirements, priorities, constraints, and the need for an Acquisition Plan should be documented by the Integrated Project Team (IPT) as a preconceptual planning process output. The IPT is composed of each organizational and customer element that affects and contributes to the project.
- *Risk Identification and Analysis.* An essential part of project planning is to ensure the risks associated with the project have been identified, analyzed, and determined to be either eliminated, mitigated, or manageable. Risk identification and analyses should be continued through succeeding phases, including preparation of the Acquisition Plan and the Project Execution Plan. Each identified risk is monitored at future CD requests and review points to ensure they have been satisfactorily addressed, eliminated, mitigated, or managed.

14.2.2 CD-0 Key milestones

- Justification of Mission Need
- Establish Project Team (IPT)
- Preliminary Environmental Strategy
- Technical Organizational Interfaces
- Integration with other projects and activities
- Independent mission need validation review
- Acquisition Strategy
- Short form Data Sheet
- Minimum technical and functional requirements
- Preconceptual development plan
- Program plan
- Technology development issues.

14.2.3 CD-0 Acquisition Sequence

The PSO organization prepares the Justification of Mission Need document (in coordination with the appropriate field office, laboratory, or contractor) and initiates preconceptual planning activities. Also, a mission validation external independent review shall be performed through OECM on all projects over $5M. These activities lead to a CD-0 determination.

14.3 Requirements for Critical Decision-1 Package

Critical Decision-1 reaffirms the mission need for a proposed project and forms the basis for the request to proceed with the preliminary design. It also establishes the preliminary estimate for the project. A Critical Decision-1 package will normally consist of a Critical Decision-1 document and a cover letter of transmittal from the proposing project manager requesting action from the Department of Energy.

Mandatory elements of the Critical Decision-1 document include

- A brief description of the proposed mission need that provides a summary statement of the program associated with the proposed project, the linkage with Department of Energy strategic and program plans, and the program conditions and drivers that require capital expenditure.
- The proposed Department of Energy program sponsor that identifies the Department of Energy program office that will provide budget support for the project during execution and later during operation.
- Preparation of a comprehensive Acquisition Plan and strategy.
- A draft Project Execution Plan (PEP). The PEP is the primary agreement on planning and objectives between the HQ program office and the field. Roles and responsibilities are established and overall project execution is defined.
- Preliminary technical functional requirements that describe the physical requirements needed to provide the programmatic capability described above. This is based on a preliminary architectural/engineering program/study that includes end user input and preliminary site criteria identification.
- Identification of high-level alternatives explored/analyzed in a Conceptual Design Report (CDR) that describes the alternatives considered during the conceptual design phase of the project.

- A preliminary (baseline range) schedule providing a high-level list of project activities, from the preconceptual phase through the start of operations, presented graphically, and showing Critical Decision milestones including schedule contingencies.
- A baseline range estimate for Total Project Cost including a high-level, conceptual estimate incorporating the Conceptual Design Report and other project costs to be funded by the sponsoring program, linked to the project Work Breakdown Structure, and including appropriate contingencies.
- A cost estimate basis/methodology that briefly describes the basis for the estimate, the contingency rationale, the assumptions for equipment, and other principal components of the total project cost (e.g., historical figures adjusted for specifics of the project, contingency level based on perceived technical risk, equipment based on today's costs escalated for inflation, etc.).
- A preliminary risk assessment that provides a statement identifying probable areas of cost, schedule, or technical risk on the proposed project.
- A finalized environmental National Environmental Policy Act strategy that presents the anticipated level of National Environmental Policy Act documentation for the project and the plan for completing it in support of the project schedule. Identification of any environmental issues that might impact the project.
- A Preliminary Hazards Analysis report.
- Preliminary safety strategy that discusses the anticipated level of safety documentation for the project, the preliminary plan for completing safety documentation in support of the proposed project schedule, and identification of safety issues that might impact the project.
- The Safeguards and Security that addresses those activities to the degree they are technical objectives and functional requirements that affect the design basis.
- Relationships or integration with other programs, projects, Department of Energy sites, programs, or facilities that have a programmatic and/or functional relationship to the proposed project. Confirmation that the project is in the related agency's plan or other Department of Energy planning document.
- A project data sheet for design..

The sponsoring agency or department shall include in the cover transmittal letter any expectation or requirement for specific turnaround time on a decision.

Key to the CD-1 package is the development of a comprehensive Acquisition Plan and strategy.

14.3.1 The Conceptual Design Report

The Conceptual Design Report documents the outcome of the conceptual design phase and forms the basis for the preliminary baseline. It is the anchor document for the initial project validation, which occurs 18 months prior to the first fiscal year of capital funding. Because the timing of validation is driven by the budget cycle and is inflexible, the Conceptual Design Report must be completed by this time to meet Critical Decision milestone requirements.

Expected elements of the Conceptual Design Report include:

- An introduction and project description containing an overview of the proposed project (design or characterization) and a synopsis of the development activities. In remediation projects, the report is a combination of applicable regulations and characterization.
- A technical objectives and mission need statement describing the technical and functional requirements to be achieved through execution of the project, as derived from the program/mission need and technical performance outlined in the Justification of Mission Need.
- An alternatives analysis that provides the details of the alternatives analysis so that the reader can clearly understand the advantages and disadvantages of each alternative. The information should include, at a minimum, life-cycle costs, operational considerations, site development considerations, relationships to other site activities, and the comparison of alternatives that then determine the preferred alternative. Life-cycle costs are to include decontamination and demolition, transition (personnel and equipment moves), utilities, and maintenance. Note: Some decontamination and decommissioning work and some backbone utility modifications may be included in other infrastructure-type projects as part of a master plan, which may preclude requiring its inclusion in a given project.
- A project schedule for the design baseline and a proposed project summary schedule including project milestones, Critical Decisions, and identification of the critical path.

- Cost estimates that include the Total Estimated Cost and Total Project Cost for the design baseline and the proposed project summary cost estimate.
- The cost estimate basis/methodology showing the basis and assumptions for the estimate and a contingency analysis.
- The funding requirements showing the proposed project funding profile to be included in the Project Data Sheet and requested in the budget. The Project Data Sheet must agree with the approved master plan when applicable.
- Preliminary design and analysis calculations.
- The summary test and acceptance criteria.
- Assessments of and strategy for:
  - Risk—identify areas of cost, schedule, or technical risk on the proposed project and show how those risks will be reduced, mitigated, or accepted.
  - National Environmental Policy Act—the level of National Environmental Policy Act documentation required for the project and the plan for completing it in support of the proposed project schedule.
  - Safety—the level of safety documentation required for the project, and the plan for completing it in support of the proposed project schedule.
  - The safeguard and security considerations for the project.
  - Site selection—the application of a coherent, defensible methodology to identify and evaluate site options.
  - Value engineering—the trade-off studies of specific project systems intended to identify potential project enhancements and associated cost savings.
  - Waste management—decontamination and decommissioning planning (where appropriate and applicable) as required to understand potential impacts on the project and take appropriate action.
- Public and/or stakeholder input (where appropriate).
- Applicable codes and standards for construction or characterization (where appropriate).
- Acquisition Strategy—the planned contracting strategy for the major components of the project, such as design, construction, characterization, or special equipment.

- Conceptual design drawings/renderings (as appropriate).
- Design alternatives.

14.3.2 CD-1 Key activities

- Define Project Objectives
- Establish existing facility baselines
- Establish initial budgets
- Review design alternatives
- Identify project codes, standards, and procedures
- Evaluate alternative site location
- Establish technical and functional requirements
- Establish project baseline ranges
- Perform safety and operability review
- Verify performance criteria
- Perform life-cycle cost analysis
- Perform project risk management
- Identify and control interfaces
- Conceptual Project Report
- Acquisition Plan
- Source Selection Plan or Business Clearances
- Project Data Sheet for Design
- Preliminary Hazard Analysis Report
- Preliminary Project Execution Plan
- Design/funding estimate
- Preliminary Baseline Ranges (cost, scope, schedule)
- PSO develops Project and Engineering Design (PED) funding pool
- Project Expectations Summary
- Statement of Work
- System Engineering Management Plan.

14.3.3 CD-1 Acquisition Sequence

Once CD-0 is obtained, the AE directs the development of the conceptual design, which results in a Conceptual Design Report, Acquisition Plan, Preliminary Hazard Analysis, draft Project Execution Plan, a design funding estimate, and preliminary baseline ranges (cost, scope, schedule) for the rest of the project. These documents are submitted for SAE/AE approval along with a PSO-validated Project data sheet for design. The PSOs establish a Project and Engineering Design (PED) funding pool for projects over $5M. These activities lead to a CD-1 (Approve Preliminary Baseline Range) determination. Where long-lead procurement is required, a phased CD-3 may be requested subject to prior budget approval and funding availability.

14.4 Requirements for Critical Decision-2

Critical Decision-2 is the approval of the project's performance baseline and is required for inclusion of project's funding in the Department of Energy Congressional Budget Request. CD-2 also authorizes the design phase to proceed as soon as funds become available. A Critical Decision-2 approval will normally include a review of the CD-1 decision, the approved Project Execution Plan, and the Preliminary (Design Report; the draft Preliminary Safety Analysis Report; the completion of a performance baseline External Independent Review, and an independent cost estimate appraising the contractor's project management system; and, the submittal of the Project Data Sheet for construction.

14.4.1 Performance Baseline Validation EIR

This is a detailed review of the entire project, including an ICE, prior to CD-2. It verifies the mission need; validates the proposed technical, cost, and schedule baseline; and assesses the overall status of the project management and control system.

14.4.2 Internal Program Review/Independent Review

The Internal Program Review will be directed by the PSO and will normally be conducted by teams assembled and funded by the Program Manager. Results of the review and the corrective action plan prepared by the Project Manager will be included in the Critical Decision-2 Package. Currently, there is a Congressionally mandated independent review requirement, that must be completed prior to preliminary design approval.

Independent Reviews. The DOE recognizes that independent reviews are valuable in assessing the status and health of its projects. An independent review may be a science-based or engineering-oriented peer review, a review of the project management structure and interrelationships between organizational components, a review targeted to a specific issue such as cost or budget, a review covering safety, or a combination. Also, for efficiency, independent reviews may be combined as appropriate.

*Internal Independent Project Reviews (IPRs)****.*** An IPR is conducted by reviewers within the department. The Deputy Secretary as SAE, or the PSO and the operations/field office manager and program managers and Federal Project Managers, may authorize or conduct IPRs as required. The PSO or Operations Field Office Manager, as part of the project management oversight process, may request IIRs through the project management support offices for any project, including MS projects. Irrespective of the organizational level initiating an IPR, the PSO or Operations/Field Office Manager notifies OECM of its intent to conduct such a review and OECM is included as an invited observer for all planned reviews. OECM coordinates the extent of participation on a case-by-case basis with the appropriate organization. Committee members of an IPR team are not drawn from the responsible program office within a program secretarial organization, related contractors from the project office, or a related funding program. Reviews may use laboratory, contractor, consultants, university, industry, or other expertise from organizations not directly funded by or related to the program/project office being reviewed.

14.4.3 CD-2 Key activities

- Review and verify IPT organization and skills
- Initiate performance reporting
- Implement trend program
- Develop project specifications, drawings, procurement packages, and construction packages
- Finalize permit requirements
- Approve safety documents
- Budget and Congressional authorization and appropriations enacted
- Update Project Execution Plan

- Commit critical equipment, requisitions
- Perform process hazards review
- Project site selection
- Update scope, cost, and schedule (performance) baselines
- Execution Readiness Independent Review
- Mission need verification
- Detailed schedules and cost estimates
- Authority responsibilities matrix
- Performance metrics
- Staffing plans
- Technical risk analysis report
- Technology development output
- Complete design model
- Conduct technical innovations evaluation.

14.4.4 CD-2 Acquisition Sequence

Once CD-1 is obtained, the project preliminary performance baseline range shall be controlled through the baseline change control process. PED funds (which are managed by the PSO, including program directors) become available for use on preliminary design and final design, baseline development, and/or a statement of work/request for proposal for a design/build contract. For long-lead procurement, a separate budget request for capital funds may be submitted prior to CD-2 for a phased CD-3 determination.

Projects must prepare a draft preliminary safety analysis report and National Environmental Policy Act documentation, as appropriate, finalize the Project Execution Plan and performance baseline, and reflect the results in the project data schedule for construction. Also, a baseline performance external independent review shall be performed through OECM on all projects over $5M.

Completion of these activities leads to a CD-2 (Approve Performance Baseline) determination.

14.5 Requirements for Critical Decision-3

Critical Decision-3 is the approval to start construction or begin execution of the project and authorizes the award of contracts as soon as funds become available. A CD-3 approval will normally require a design review and subsequent approval of the final design and an execution external readiness independent review. Critical Decision-3 is requested with a letter from the project manager to the DOE AE, who has the authority to approve a CD-3 and formally notify the program sponsor and project manager.

14.5.1 Final Design Review

The final design review is a technical review of the standard and special specifications, drawings, and other related reports (e.g., energy conservation report). The purpose of the review is to ensure that the design complies with user and agency requirements and accepted standards. The process includes:

- Assessing technical adequacy and conformance with agency and customer requirements, codes, standards, and other criteria such as budgetary constraints
- Identifying consistent problems and errors, and lessons learned to pass on to future projects
- Managing reviewer participation and providing a process for review comment response and resolution.

The Project Manager coordinates the review by providing the design documents to qualified participants in the fields of Environment, Safety, and Health; all applicable disciplines of engineering, architecture, controls, communications, security, operations, maintenance, fire protection, energy conservation, and other areas as necessary. Other reviewers include any technical experts the DOE deems appropriate, along with the user representatives.

The project manager shall document all review comments and ensure they are resolved by incorporating changes or documenting the reason for not doing so.

14.5.2 Final Design Package

The package will include final drawings, specifications, a detailed cost estimate, detailed schedule calculations and design analyses, and a final energy conservation report. The package shall be in a form ready to send out to bid or a request for quotation.

External Independent Review (EIR)

An EIR is conducted by reviewers outside the Department. OECM will select an appropriate contracting agency to contract for such reviews, excluding the M&O/ M&I contractors. The actual selection of reviewers, contract management and contact with the Contracting Officer, and dialogue with the EIR contractor on matters pertaining to the contract are the sole purview of OECM. OECM may make nonproject/nonprogram funds available to pay for the EIR contractor and for travel expenses of OECM staff participating in such reviews; however, OECM funds are not available for PSO staff support. The PSO's project management support office provides coordination for the EIR contractor on site, resolves issues of schedule and access while on site, gathers and provides requested and proffered information to the reviewer, and responds to the reviewer on errors of fact or needed clarification. The project management support office does not provide direction to the reviewer as to the content of the reviewer's report.

EIRs are managed by OECM as DOE's agent. Line management, including the Deputy Secretary, PSO, or a program or project organization within the PSO may request an EIR. EIRs also may be initiated in response to an external requirement, however, reviews, studies, or investigations conducted by the General Accounting Office or the Office of the Inspector General are not considered EIRs for DOE purposes. OECM coordinates all such reviews with the appropriate PSO to define review scope, choose an optimal time during the acquisition process, minimize impact on the project of conducting multiple reviews, and evaluate credentials of potential reviewing organizations and individuals.

Independent Cost Estimate

An Independent Cost Estimate review may be proposed to verify the detailed cost estimate included in the final design. An independent firm or agency will conduct the review so that the two estimates can be compared and determined to be reasonable. If the cost estimates are substantially different, the two shall be compared to identify omissions, duplications, etc.

14.5.3 CD-3 Key Activities

- Finalize field support plan
- Review Safety Action Plan

- Perform final design review
- Prepare definitive estimate
- Detailed resource-loaded schedule
- Prepare equipment and material requisitions
- Approve to initiate construction activities
- Complete procurements of materials and equipment
- Start systems completion
- Work off punch lists
- Develop Turnover and Startup Plan
- Operating and Maintenance Manuals
- Execution Readiness External Independent Review

14.5.4 CD-3 Acquisition Sequence

Once CD-2 is obtained, the project can be included in the DOE budget submission process. The Final Design would continue with PED funds through completion of the design. If requested and approved, long-lead procurement funds are committed. The final Safety Analysis Report is to be submitted for approval and the DOE safety evaluation report shall be issued, as appropriate. An Execution Readiness External Independent Review shall be performed through OECM on MS projects and, through the appropriate AE, for other projects over $5M. The Project Execution Plan and performance baseline shall be updated, if required. These activities lead to a CD-3 (Approve Start of Construction) determination.

14.5.5 Critical Decision-3 Request

Once the final design review is complete, the design documents are updated, and the Execution Readiness Independent Review is completed, the project manager sends a Critical Decision-3 Request Letter to the SAE/AE requesting approval for CD-3, Approve Start Construction. The letter will include the approval deadline necessary to maintain the project schedule.

14.6 Requirements for Critical Decision-4

CD-4 is the transition of project deliverables to the user for operations. Prior to obtaining CD-4, Approval, the contractor will normally prepare a letter of intent to occupy or begin operation with an occupancy checklist and a readiness assessment or review from the occupant. A Final Cost Report is required for closeout. Final Cost Reports will vary by site and are not prepared until after all contracts and work orders are closed and all costs are collected. The Final Cost Report may or may not be completed prior to obtaining approval of CD-4.

14.6.1 Letter of Intent to Occupy and Occupancy Checklist

Once construction is complete, the project manager will use a checklist to ensure the facility or action is safe and functional before occupancy. The goal of the checklist is to ensure that at least the minimum building, life, safety, and security requirements are met prior to delivering the product to the user, and to make an informed decision on when to occupy. The items on the checklist may be prioritized into those items that: are mandatory before occupancy, must be completed prior to commencing operations, and can be completed after the building is occupied and operational. Each project shall establish the checklist according to the items that are applicable to the specific site and to the specific facility. The project manager and the responsible Department of Energy field office must allow occupancy based upon a partially completed checklist. This checklist and its content are not mandatory, and DOE sites may vary in how they establish final acceptance of a facility for beneficial occupancy.

The project manager will send the letter of intent to occupy with the fully completed checklist to the field office for approval and forwarding to the program sponsor and project program manager as part of the CD-4 package.

14.6.2 Readiness Assessment/Review

Early in the project, as part of readiness activities, a level of operational readiness will be determined so the user will know what type of assessment or report is required prior to operation. The facility user is required to provide the appropriate level of operational readiness review prior to occupying or operating the facility. The readiness plan may include a phased approach to readiness so that a staged occupancy is possible. Approval authority for readiness reviews varies depending upon the type and level of hazards involved.

14.6.3 CD-4 Key activities

- Startup testing
- Prepare intent to occupy and occupancy checklist
- Initiate document and project closeout process
- Completion of construction
- Perform systems completion testing
- Verify performance criteria
- Prepare lessons learned report
- Readiness self-assessment
- Approve for acceptance
- Prepare and complete as-built drawings, if required
- Prepare project completion report
- Complete financial closeout
- Satisfaction meeting.

14.6.4 CD-4 Acquisition Sequence

Once CD-4 is obtained, execute and complete all mission activities, including construction where required; complete transition to operations planning activities, including DOE approval of Environmental, Safety and Health documentation, an operational readiness review, and an acceptance report. These activities lead to a CD-4 (Approve Start of Operations or Project Closeout) determination.

14.6.5 Critical Decision-4 Request for Completion/Acceptance

The project manager prepares a letter requesting CD-4 and submits it to the field office for approval. The field office shall forward the approved CD-4 request to the program sponsor and the program manager.

Practice 15

15

Procurement and Contracting

15 CONTRACTING AND PROCUREMENT

Project contracting and procurement management includes the processes required to acquire goods and services from outside the performing organization. For the purposes of this discussion, it does not include the acquisition of capital assets. These processes include:

- Procurement planning: what to procure and when.
- Solicitation planning: product requirements and identifying potential sources.
- Solicitation: obtaining quotations, bids, offers or proposals, as appropriate.
- Source selection: awarding the bid.
- Contract administration: the relationship with the seller.
- Contract closeout: completion and settlement of the contract including resolution of any open items.

These processes interact not only with each other, but with processes in other knowledge areas. Each process may involve effort from one or more individuals or groups of individuals based on the needs of the project. Process interactions are an integral part of the contracting and procurement process.

Project procurement management is discussed from the perspective of the buyer in the buyer-seller relationship.

The *seller* will typically manage their work as a project. In such cases:

- The *buyer* becomes the customer and is a key stakeholder for the seller.
- The *seller's* project management team must be concerned with all the processes of project management.
- The terms and conditions of the contract become a key input to many of the seller's processes. The contract may contain the input (e.g., major deliverables, key milestones, cost objectives) or it may limit the project team's options (e.g., buyer approval of staffing decisions is often required on design projects).

15.1 Procurement Planning

Procurement planning is the process of identifying which project needs can be best met by procuring products or services outside the project organization, and includes consideration of whether to procure, how to procure, what to procure, how much to procure, and when to procure. Procurement planning should also include consideration of potential subcontracts, particularly if the buyer wishes to exercise some degree of influence or control over subcontracting decisions. The project management team shall seek support from specialists in the disciplines of contracting and procurement when needed.

When the project does not obtain products and services from outside the organization, the processes from solicitation planning through contract closeout would normally not be performed. This is most often associated with research and development projects, and on many smaller, in-house projects when the cost of finding and managing an external resource may exceed the potential savings.

15.1.1 Inputs to Procurement Planning:

- Scope statement: The scope statement describes current project boundaries and provides important information about project needs and strategies that must be considered during procurement planning.
- Product description: The description of the product provides important information concerning any technical issues or concerns that need to be considered during procurement planning.
- Procurement resources: An estimate of the resources needed to support the project.
- Market conditions: The procurement planning process shall consider what products and services are available in the marketplace. Also, are multiple sources of information available?
- Constraints: Constraints are factors that limit the buyer's options. One of the most common constraints for DOE projects is the availability and timing of funds.

15.1.2 Tools and Techniques for Procurement Planning

- Make-or-buy analysis: This technique can be used to determine whether a particular product can be produced cost-effectively by the performing organization, or should be procured.

The make-buy process may compare the cost of construction forces on site (when available) implementing a project or portion of a project versus buying the services with fix-priced subcontracts. The guiding principles to a make-or-buy analysis process include:

- The process is auditable to ensure financial analysis guidelines are consistent.
- The process yields qualified sources with the lowest evaluated cost.
- The process is unbiased, i.e., estimates of “make” cost and “buy” cost are prepared by independent organizations.
- The process is nonexclusionary. Activities will not be performed in-house solely because of qualitative criteria.
- The Project Manager should initiate the make-or-buy analysis during the conceptual phase prior to CD-2.
- Expert Judgement: Expert judgment will often be required to assess the inputs to this process.
- Contract Type Selection: Different types of contracts are more or less appropriate for different types of purchases. Contracts generally fall into one of three broad categories:
  - Fixed Price or Lump Sum Contracts: This category of contract involves a fixed total price for a well-defined product.
  - Cost Reimbursable Contracts: This category of contract involves payment (reimbursement) to the seller for actual costs. Cost reimbursable contracts often include incentives for meeting or exceeding selected project objectives such as schedule targets or total cost.
  - Unit Price Contracts: The seller is paid a preset amount per unit of service, and the total value of the contract is a function of the quantities needed to complete the work.

15.1.3 Outputs from Contracting and Procurement Planning

- Contracting and Procurement Management Plan: The contracting and procurement management plan (an element of the PEP) shall describe how the remaining procurement processes (from solicitation planning through contract closeout) will be managed. For example:

— What type of contracts will be used?

— Will independent estimates be needed as evaluation criteria?

— Will standardized procurement documents are needed, and how will multiple providers be managed?

— How will procurement be coordinated with other project aspects such as scheduling and performance reporting?

The plan should include a listing of contracts/procurements required including a listing of key dates (e.g., date of issuance of approved specification, procurement start, receipt of approved requisition package by Procurement, contract award date, product delivery date, intermediate milestones, etc.).

- Statement(s) of Work: The statement or scope of work (SOW) describes the procurement in sufficient detail to allow prospective sellers to determine if they are capable of providing the item. “Sufficient detail” may vary based on the nature of the item, the needs of the buyer, or the expected contract form.

The statement of work shall be as clear, complete and concise as possible. The SOW should include a description of any collateral services required, such as performance reporting, spare parts or post-project operational support for the procured item. In some applications, there are specific content and format requirements for a SOW.

A recommended practice is to require the successful bidder to prepare a document that describes their understanding of the scope of work. This document must be submitted prior to initiation of work and then reviewed with the buyer to assure a complete understanding of the work to be performed and the product expected.

15.2 Solicitation Planning

Solicitation planning involves preparing the documents needed to support solicitation of bids, quotes, or proposals.

15.2.1 Inputs to Solicitation Planning

- Contracting and Procurement Management Plan.
- Statement(s) of work.
- Project schedule: Solicitation planning shall be closely coordinated with the project schedule.

15.2.2 Tools and Techniques for Solicitation Planning

- Standard Forms: Standard forms may include contracts, descriptions of procurement items, or standardized versions of all or part of the needed bid documents.
- Expert Judgement: Expert judgment should be sought and used as needed.

15.2.3 Outputs From Solicitation Planning

- Contracting and Procurement Documents: Contracting and Procurement documents are used to solicit proposals from prospective sellers. Common names for different types of procurement documents include Invitation for Bid (IFB), Request for Proposal (RFP), Request for Quotation (RFQ), Invitation for Negotiation, and Contractor Initial Response.

  Contracting and procurement documents shall be structured to facilitate accurate and complete responses from prospective sellers, and should always include the relevant statement of work, a description of the desired form of the response and any required contractual provisions (e.g., a copy of a model contract, nondisclosure provisions). Some or all of the content and structure of contracting and procurement documents may be defined by regulation. Procurement documents shall be rigorous enough to ensure consistent, comparable responses, but flexible enough to allow consideration of seller suggestions for better ways to satisfy the requirements.

- Evaluation Criteria: Evaluation criteria are used to rate or score proposals. They may be objective or subjective, and are often included as part of the procurement documents.

  Evaluation criteria may be limited to purchase price if the contract/procurement item is known to be readily available from a number of acceptable sources When this is not the case, other criteria must be identified and documented to support an integrated assessment. For example:

  — Understanding of need—as demonstrated by the seller's proposal.

  — Overall or life cycle cost—will the selected seller produce the lowest total cost (purchase cost plus operating cost)?

  — Technical capability—does the seller have, or can the seller be reasonably expected to acquire, the technical skills and knowledge needed?

—Management approach—does the seller have, or can the seller be reasonably expected to develop, management processes and procedures to ensure a successful project?

—Financial capacity—does the seller have, or can the seller reasonably be expected to obtain, the financial resources needed?

—Past performance—does the seller have a past history of performance/ nonperformance and will the caller provide "best value" for the projects.

15.3 Solicitation

Solicitation involves obtaining information (bids, proposals) from prospective sellers on how project needs can best be met. Most of the effort in this process is expended by the prospective sellers, normally at no cost to the project.

15.3.1 Inputs to Solicitation

- Contracting and Procurement Documents
- Qualified Seller Lists (QSLs): Most organizations maintain lists or files with information on prospective sellers, known as qualified seller lists (QSLs). A QSL is a composite of quality-related information for suppliers, obtained from various sources. If QSLs are not available, the project team shall develop its own sources. General information is widely available through library directories, relevant local associations, trade catalogs, and similar sources. Detailed information may require site visits or contact with previous customers.

15.3.2 Tools and Techniques for Solicitation

- Bidder Conferences: Bidder conferences are meetings with prospective sellers prior to preparation of a proposal. They are used to ensure that all prospective sellers have a clear, common understanding of the procurement. Responses to questions may be incorporated into the procurement documents as amendments.
- Advertising: Existing lists of potential sellers can often be expanded by placing advertisements in general circulation publications such as newspapers or in specialty publications such as professional journals. DOE requires public advertising of subcontracts on a government contract.

15.3.3 Outputs from Solicitation

- Proposals: Proposals are seller-prepared documents that describe the seller's ability and willingness to provide the requested product. They are prepared in accordance with the requirements of the relevant procurement documents.

15.4 Source Selection

Source selection involves the receipt of bids or proposals and the application of the evaluation criteria to select a provider. This process is seldom straightforward.

- Price may be the primary determinant for an off-the-shelf item, but the lowest proposed price may not be the lowest *cost* if the seller proves unable to deliver the product in a timely manner.
- Proposals are often separated into technical (approach) and commercial (price) sections with each evaluated separately.
- Multiple sources may be required for critical products. In this case, past performance should be considered.
- Rank and order proposals to establish a negotiating sequence.

On major procurement items, this process may be iterated. A short list of qualified sellers will be selected based on a preliminary proposal, and then a more detailed evaluation will be conducted based on a more detailed and comprehensive proposal.

15.4.1 Inputs to Source Selection

- Proposals
- Evaluation Criteria
- Organizational Policies: Any and all of the organizations involved in the project may have formal or informal policies that can affect the evaluation of proposals.

15.4.2 Tools and Techniques for Source Selection

- Contract Negotiation: Contract negotiation involves clarification and mutual agreement on the structure and requirements of the contract prior to signing of the contract. To the extent possible, final contract language should reflect all agreements reached. Subjects covered generally include, but are not limited to, responsibilities and authorities, applicable terms and law, technical and business management approaches, contract financing, and price.

  This process should obtain goods and services of the required quality, at the lowest possible cost, in accordance with the specified schedule and consistent with the terms and conditions. Preparation is the primary key to successful negotiation.

  The following guidelines should lead to successful negotiation:

  — Develop a negotiation plan outline. Preparing and planning goals, tactics, and strategy are most important.

  — Choose a negotiation team and include only required disciplines.

  — Agree, in advance, upon realistic cost/commercial/technical objectives as well as a negotiation plan.

  — Be informed regarding the suppliers/contractors and their representatives.

  — Negotiate in DOE or requestor facilities to increase "control" over the process.

  — Negotiate only with supplier/contractor representatives who have the authority to make commitments or concessions.

  — Let the lead negotiator control the negotiation. Their duty is to control any sudden changes, surprises, breakdowns in bargaining and other nondirectional situations.

  — Weighting system: A weighting system is a method for quantifying qualitative data in order to minimize the effect of personal prejudice on source selection. Most systems involve: (1) assigning a numerical weight to each of the evaluation criteria, (2) rating the prospective sellers on each criterion, (3) multiplying the weight by the rating, and (4) totaling the resultant products to compute an overall score.

  — Screening System: A screening system involves establishing minimum performance requirements for one or more of the evaluation criteria.

— Independent Estimates: When needed, the project shall prepare/provide an independent or government estimates as a check on proposed pricing. Significant differences from these estimates may be an indication that the SOW was not adequate or that the prospective seller either misunderstood or failed to respond fully to the SOW.

15.4.3 Outputs from Source Selection

- Contract: A contract is a mutually binding agreement which obligates the seller to provide the specified product and obligates the buyer to pay for it. A contract is a legal relationship subject to remedy in the courts.

  Although all project documents are subject to some form of review and approval, the legally binding nature of a contract usually means that it will be subjected to a more extensive approval process. In all cases, a primary focus of the review and approval process should be to ensure that the contract language describes a product or service that will satisfy the need identified. In the case of major projects undertaken by public agencies, the review process may even include public review of the agreement.

15.5 CONTRACT ADMINISTRATION

Contract administration is the process of ensuring that the seller's performance meets contractual requirements. On larger projects with multiple product and service providers, a key aspect of contract administration is managing the interfaces among the various providers. The legal nature of the contractual relationship makes it imperative that the project team be acutely aware of the legal implications of actions taken when administering the contract.

- Project work release systems to authorize the contractor's work at the appropriate time.
- Performance reporting to monitor contractor cost, schedule, and technical performance.
- Quality control to inspect and verify the adequacy of the contractor's product.
- Change control to ensure that changes are properly approved and that all those with a need-to-know are aware of such changes.

Once a contract is awarded, a Notice to Proceed is issued. The Notice to Proceed is a formal notification to the contractor that work may begin. However, mobilization does not occur until after initial submittal requirements are met.

Submittal requirements for contracts may be found in the specification or scope of work and in the special conditions/general provisions of the procurement package. The procurement package should define the submittal schedule. Submittals may require approval prior to the start of construction or fabrication. The timing of these submittals is important because of their potential impact on the schedule.

Preparing submittals involves the following activities:

- A submittal identification tracking system should be established.
- The submittal review process should be clearly defined, and implemented.
- A submittal log should be used to establish the system/component review matrix, description of item, date received, date transmitted to review organization, date comments returned, resolution and date of final approval.
- Submittals must accurately represent the equipment specified, delivered and installed at the construction site.
- Each organization should provide timely turnaround of submittals. An agreement of standard turnaround time should be obtained.
- A single point of contact for processing of submittals should be established to ensure timely receipt, review and approvals. This applies to both the project and reviewing personnel/organizations.
- Because contract administration also has a financial management component, payment terms should be defined within the contract and should involve a specific linkage between progress and compensation.

Construction contracts should require the subcontractor to have an approved schedule prior to starting construction activities. Supplemental schedules may be required for the project duration, i.e., thirty days or four weeks rolling. These schedules should identify, at a minimum, the milestone dates defined in the subcontract agreement. Examples of milestone dates are construction start, mechanical complete (system operable), and physical complete (all punch list items complete). Preparing schedules involves the following activities.

- The overall project schedule should include the dollar values associated with each activity. These values should sum to the total amount of the subcontract.

- Supplemental schedules should be required that identify and include milestone dates that are specified in the contract documentation.
- The contractor's schedule should provide a Work Breakdown Structure (WBS) bar chart and "S" curve resource-loaded schedule. This schedule should highlight the contractor's critical path.
- The contractor's baseline contract schedule should always be maintained. Any negotiated baseline schedule changes should be incorporated into the baseline schedule in a timely manner.

When work activities are completed, and verified by the project, payment requests may be submitted and approved. Progress payments are based on the values loaded into the schedule minus retainage, which is usually ten percent of the requested amount.

The Project Manager and responsible project controls personnel should track invoices submitted versus payments to the contractor. The accounting system must capture the delta in actual and invoiced cost to accurately report contractor costs against performance.

Contract administration also has a financial management component. Payment terms shall be defined within the contract and should involve a specific linkage between progress and compensation.

15.5.1 Inputs to Contract Administration

- Contract
- Work Results: The seller's work results—which deliverables have been completed and which have not, to what extent are quality standards being met, what costs have been incurred or committed, etc.
- Change Requests: Change requests may include modifications to the terms of the contract or to the description of the product or service to be provided.

  During the execution of a subcontract, the need to change the contract may occur. This may be the result of a request and agreement. Requests for changes must be submitted in writing. Once negotiated between the supplier and procurement representative, a change order will be issued. Upon issuance of the change order, the contract has been officially amended.

The key issue that all Project Managers face through the course of a project is managing change. Project Managers should remain aware of the following when managing change:

— Close management and control of change can help ensure project success.

— Changes to contracts/procurement documentation baselines must be by approved documentation through the authorized representative (procurement).

— Change documentation must provide an adequate description of the change's impacts to baseline contract cost and schedule supported by an independent cost estimate.

— The contractor should be forced to submit claims in a timely manner.

— The Project Manager should be involved in the negotiation of any major changes.

Sellers must be monitored to ensure that all work is in compliance with contract requirements. The project must keep the subcontractor on schedule, enforce safety procedures, approve payment, educate the subcontractor on site procedures and perform many other tasks as part of the payment process.

15.5.2 Tools and Techniques for Contract Administration

- Contract Change Control System: A contract change control system defines the process by which the contract may be modified, and includes the paperwork, tracking systems, dispute resolution procedures and approval levels necessary for authorizing changes. The contract change control system should be integrated with the project change control system.

- Performance Reporting: Performance reporting provides information about how effectively the seller is achieving the contractual objective. Contract performance reporting should be integrated with overall project performance reporting.

- Payment System: Payments to the seller are usually handled by the accounts payable system of the performing organization. The system must include appropriate reviews and approvals by the project management team.

- Incentive: Some contracts are amenable to incentives as a method of rewarding performance. If used, this technique must be carefully controlled and monitored to assure the process adds value.

15.5.3 Outputs From contract Administration

- Correspondence: Written documentation of certain aspects of buyer/seller communications, such as telephone conversations and meeting minutes.
- Contract Changes: Changes (approved and unapproved) are used as appropriate to upgrade the PEP or other relevant project documentation.
- Payment Requests: This assumes that the project is using an external payment system. If the project has its own internal system, the output here would simply be "payments".
- Historical Records: Historical records of the subcontractor's performance starting from award and proceeding through closeout must be maintained. Also, a collection of factually documented observations and records for the project's protection is kept in the event legal actions (claims) are brought against the project by the seller.

15.6 CONTRACT CLOSEOUT

Contract closeout is similar to administrative closure in that it involves both product verification and administrative closeout. The contract terms and conditions may prescribe specific procedures for contract closeout. Early termination of a contract and termination for the convenience of the government are special cases of contract closeout.

15.6.1 Inputs to Contract Closeout

- Contract Documentation: Contract documentation includes, but is not limited to, the contract itself along with all supporting schedules, requested and approved contract changes, any seller-developed technical documentation, seller performance reports, financial documents such as invoices and payment records, and the results of any contract-related inspections.

15.6.2 Tools and Techniques For Contract Closeout

Procurement Audits: A procurement audit is a structured review of the procurement process from procurement planning through contract administration. The objective of a procurement audit is to identity successes and failures and lessons learned.

- Acceptance Walkdown or Inspection: The procurement documents must specify the process for turnover and acceptance of the equipment or service.

  The project team and customer representatives must be involved in walkdowns and acceptance of equipment from contractors. After completion and turnover, the subcontractor is relieved from further responsibility except in three circumstances:

  —Latent Defects—A defect existed at the time of acceptance but was not discoverable through reasonable inspection.

  —Fraud—The subcontractor's intent was to deceive the project.

  —Warranties—Continue for a specified time from the date the mechanical completion certificate is completed.

These items must be managed to ensure DOE's interests are protected.

15.6.3 Outputs From Contract Closeout

- Contract File: A complete set of indexed records should be prepared for inclusion with the final project records.
- Formal Acceptance and Closure: The person or organization responsible for contract administration should provide the seller with formal written notice that the contract has been completed. Requirements for formal acceptance and closure are usually defined in the contract.

Practice 16

16

Test and Startup Acceptance

16 TEST AND STARTUP ACCEPTANCE

The purpose of construction is to provide a functional product that operates as intended. This purpose cannot be achieved without a formal commissioning process which includes a transition to operation. This transition is best achieved by:

- early planning, organizing, and preparation of the transition.
- systematically performing required inspection and testing.
- providing adequate documentation of commissioning and transition activities.

Typically, all aspects of a formal construction project are under control of the construction organization, with oversight of the commissioning authority at the start of transition activity. By the time transition is completed, the construction organization has relinquished all control and the user organization and their operations and maintenance staff have total responsibility. Jurisdictional control of all structures, systems, and components must be clearly defined and controlled throughout the transition process. The project manager and commissioning authority are responsible for developing and implementing a jurisdictional control system that is appropriate for the size, complexity, and operational status of the construction activity and associated conditions. If the construction activity involves tie-ins to existing functional systems that remain operational, the jurisdictional control process should be described in detail. For construction activity that involves multiple "functional systems," the jurisdictional control system should address control of individual "functional systems." For formal construction projects, the jurisdictional control system should be described in the project execution plan; a separate commissioning plan may be desirable. Additional guidance on in-house energy management can be found in 10CFR435 for Federal buildings and in DOE O 430.2. DOE has published a "Model Commissioning Plan and Guide Specifications," version 2.05, to assist in federal building commissioning.

16.1 TYPICAL STARTUP TESTING ACTIVITIES/LOGIC

Regardless of the project, there are typical activities or elements that when complete can result in an orderly project transition and commissioning process. However, this practice imposes no requirement to use the typical activities and logic. If the project manager believes that the typical process would be beneficial for their particular construction activity, it may be followed. On the other hand, the typical activities and logic may be tailored for application to construction activity of any size (both formal construction projects and minor construction activity).

16.1.1 Define Functional Systems

As soon as adequate detailed design and design basis documentation is available, the construction activity should be broken down into "functional systems." Typically, this breakdown will coincide with the project's work breakdown structure. The "functional systems" consist of a group of components that when taken together form a logical group that allow meaningful testing to be performed. The "functional system" breakdown may or may not correspond to the permanent plant system breakdown. For some construction activity (e.g., minor construction activity), there may be a single "functional system" that is comprised of the entire construction activity. For large complex formal construction projects, there may be many "functional systems." For any construction activity, the sum of all "functional systems" equals the total construction activity.

16.1.2 Establish Logic for System Startup Sequence

Construction activities that have multiple "functional systems" usually have to be tested and started in a particular logical sequence. (As an example, if System A provides electrical power to a motor in System B, then System A must be tested and started prior to testing and starting System B.) Establishing the "functional system" logical startup sequence is a prerequisite to developing the commissioning plan and critical path commissioning schedule.

16.1.3 Develop Critical Path Commissioning Startup Schedule

Each "functional system" should be evaluated to establish a reasonable startup testing duration. The durations combined with the sequence logic are used to form a critical path commissioning startup schedule. This schedule establishes the date that each construction complete "functional system" is needed. Once the "functional system" need dates are established, they should be clearly communicated to the physical construction organization so that physical construction activity can be focused and directed to produce the "functional systems" as needed to support the startup effort.

16.1.4 Integrate Construction Schedule with Commissioning Startup Schedule

For large formal construction projects (where construction may take years), construction management's focus should shift as the project progresses. For most of the physical construction period, construction management's focus is typically on bulk quantity installation (e.g., cubic yards of concrete, tons of structural steel, feet of large bore and small bore pipe).

As physical construction becomes approximately 20 percent complete, and startup "functional system" requirements become known, the focus should shift from bulk quantity installation to "functional systems" completion. Typically, the physical construction schedule does not contain easily identifiable "functional systems." For construction activity (both formal construction project and minor construction activity) with multiple 'functional systems" defined, considerable construction schedule refinement is frequently required to integrate the physical construction schedule with the commissioning and startup schedule. This refinement of the construction schedule as physical construction progresses is a normal part of the transition to operation process and should be anticipated and planned.

For construction activity (both minor construction activity and formal construction projects) that consists of a single "functional system," integration of the construction schedule with the commissioning startup schedule is simple: finish physical construction so that commissioning activities may proceed.

16.1.5 Provide "Construction Complete" Functional Systems

For commissioning activities to progress smoothly and rapidly, construction complete "functional systems" should be made available when needed. Supporting the commissioning startup schedule (i.e., providing construction complete "functional systems" when needed) becomes the construction organization's prime objective as physical construction approaches completion.

As "functional systems" become "construction complete" and are made available for functional performance testing, a jurisdictional transfer (from the construction organization to the testing organization, test engineer, and/or commissioning authority) typically occurs. The jurisdictional transfer allows the testing organization, test engineer, and commissioning authority to control the status of the system and aids in restricting construction personnel from changing physical parameters of transferred systems. For large formal construction projects (with multiple "functional systems") a formal process for system jurisdictional control shall be established.

As functional and system performance testing begins (for projects with multiple "functional systems"), a new category of safety hazards are introduced into the project; physical construction activity will necessarily occur in parallel with testing. Interrelationships should be documented and well understood to ensure the safety of construction and testing personnel. The commissioning startup plan should include pre-startup and functional performance test meetings prior to commencing these activities. In accordance with the ISMS, safety hazards must be identified, analyzed, and controlled prior to initiating testing work.

16.1.6 Develop Test Procedures

Part of the commissioning effort includes providing acceptance criteria and test requirements. This information is provided in the design basis and other engineering and design documentation. These criteria and requirements should be identified for each "functional system" as a prerequisite to developing each test procedure. Multiple test procedures (e.g., Acceptance Test Procedure, and Operational Test Procedure) or a single test procedure may be developed for each "functional system." These procedures should be incorporated in the test plan, which is part of the more comprehensive commissioning plan. Test program and procedure requirements include:

- Tests shall be controlled, planned, performed, and documented.
- The commissioning authority generally representing the design authority shall provide test requirements and acceptance criteria.
- Test procedures shall be reviewed and approved in accordance with the applicable requirements.
- Test procedure results shall be documented.
- Acceptance testing must be witnessed and/or inspected by personnel who are independent of the work performing organization.
- Test results shall be documented.
- Test results shall be evaluated for acceptability by the commissioning authority.

Startup reports should be generated by the commissioning authority to the user organization. These reports should indicated any discrepancies or failures. These deficiencies should be added to the issues log (a type of ongoing commissioning punch list).

Test procedure sign-offs fall into three distinct categories:

- Approval of the test procedure prior to use, which documents that the test procedure is adequate for its intended purpose.
- Step-by-step sign-off in the procedure as the testing is being performed, which documents that each step (or group of steps) has been performed (and witnessed if required) and that specified test data has been collected.
- Review, analysis, and approval of test results, which documents that system performance has been achieved (acceptance and functional criteria have been met).

Consideration should be given to obtaining review and/or approval of test procedures from the user organization and/or their operations and maintenance departments. This is particularly appropriate if they will be involved in performing the test.

16.1.7 Construction Acceptance Testing

Construction/installation acceptance testing is designed to test and document that physical installation and startup activities have been completed in accordance with approved engineering and design documents. It is performed prior to functional performance testing. Because construction acceptance testing is typically component, not system operation, it provides limited assurance of the adequacy of a constructed product to perform its intended function (i.e., a correctly built design may not perform acceptably).

For formal construction projects, construction acceptance testing shall be performed in accordance with approved test procedures. Typical construction acceptance testing activities (depending on the particular system being tested) include, visual inspections, continuity checks, verification of equipment rotation, vibration and alignment including baselines, filling and flushing, hydrostatic pressure testing, instrument and control calibration, and loop checks. Documentation for these activities may include signed off installation verification forms or checklists. These forms or checklists should be signed off by the installation technicians and/or the Results from construction acceptance testing shall be evaluated (by engineering and design) to ensure that requirements have been satisfied.

Frequently, the construction activity involves interface with existing structures, systems, and components (e.g., modification or addition to existing facilities). All testing activity that has the potential to affect an existing facility shall be closely coordinated with the facility to assure that unplanned (and potentially unsafe) conditions do not occur. This applies to both acceptance and functional performance testing. All testing activities shall be planned and conducted to support applicable conduct of operations requirements. In accordance with the ISMS, safety hazards that may occur as a result of testing must be identified, analyzed, and controlled prior to the start of each test. Particular care must be exercised when nuclear materials are involved which have the potential to create a criticality accident.

As "functional systems" successfully complete installation and startup testing, a jurisdictional transfer (from the construction/installation organization to the functional performance testing organization) typically occurs. The jurisdictional transfer allows the testing organizations to control the status of the system and aids in restricting construction and other testing personnel, such as the test and balance firm, from changing physical parameters of transferred systems during functional performance testing. For large formal construction projects (with multiple "functional systems"), a formal process for system jurisdictional control shall be established.

For formal construction projects, successful completion of construction/installation acceptance testing constitutes a significant project milestone—physical construction is complete. This is officially documented in a construction completion document. This document is required for formal construction projects, and is optional for minor construction activity.

For minor construction activity, construction acceptance may not require a formal written procedure and may be as simple as performing a visual inspection to assure that the physical construction/installation has been completed.

16.1.8 Functional Performance Testing

Functional performance testing is designed to verify and document that construction complete systems and projects meet specified performance requirements. It is performed after construction/installation acceptance testing, and demonstrates that the constructed product is capable of performing its intended function/mission.

For facility-type construction activity (e.g., a nuclear process plant), functional performance testing has traditionally been performed by user personnel or their assigned commissioning authority. This practice places no restriction on what organization performs functional performance testing. The commissioning authority working with the project manager is responsible to assure that required functional performance testing activities are defined, planned, scheduled, staffed, performed, and documented. They are also responsible to assure that clear jurisdictional control is maintained throughout the startup testing process performance requirements defined in the technical baseline document (final basis for design) during the conceptual phase.

For formal construction projects, functional performance testing is usually performed in accordance with approved functional performance test procedures. Typical functional performance testing activities (depending on the particular system being tested) include, initial operation of components and systems, operating systems independently at normal parameters, and operating systems together through various operating levels and through specified transients. Results from functional performance testing shall be evaluated (by the commissioning authority) to ensure that requirements have been satisfied.

Much of the construction activity involves interface with existing structures, systems, and components (e.g., modification or addition to existing facilities). All testing activity that has the potential to affect an existing facility shall be closely coordinated with the facility to assure that unplanned (and potentially unsafe) conditions do not occur. All testing activities shall be planned and conducted to support applicable conduct of operations requirements. In accordance with the ISMS, safety hazards that may occur as a result of testing must be identified, analyzed, and controlled prior to the start of each test. Part of the hazard analysis/ accident analysis identifies hazards and potential accidents that exist during the startup process. Particular care must be exercised when nuclear materials are involved which have the potential to create a contamination event or incident, or a criticality accident.

For formal construction projects, successful completion of functional performance testing completes the project. This is officially documented in a construction completion document as well as the final commissioning report. This form is required for formal construction projects and is optional for minor construction activity.

For minor construction activity, functional performance testing may not require a formal written procedure and may be as simple as demonstrating functionality.

16.1.9 Prepare for Facility Startup

Functional and operations performance testing is designed to measure and document the adequacy of the constructed or installed system(s) to perform their intended function(s) and is focused on the functional adequacy of installed hardware.

Facility startup readiness (which occurs after functional performance testing) expands the focus to include not only hardware, but also the adequacy of personnel, procedures, and administrative processes necessary to support and maintain safe operations. Assessment of the need for a readiness review should take place early enough to allow preparation for the review to be completed by the end of the execution phase.

16.1.10 Review, Analyze, and Approve Test Results

Approval of functional and operational test results is the major milestone for any construction activity. Successful results from functional performance testing assures that the constructed product is capable of achieving the functional and performance requirements as intended in the technical baseline document (final basis for design) during the conceptual phase.

16.2 Construction Activity Closeout and Documentation

Typical construction activity closeout and documentation activities are described in this section. These activities and logic may be tailored for application to construction activity of any size (both formal construction projects and minor construction activity). All closeouts and documentation activity shall be performed consistent with the content of the PEP and commissioning plan, if generated.

16.2.1 Punch List

As physical construction nears completion (approximately 95 percent complete), a detailed punch list which itemizes remaining construction work shall be prepared and maintained by the project. Project participants (e.g., commissioning, engineering, quality control, construction, startup, operations) should assist the project in development of the project punch list. Care should be taken to only include items on the punch list that are part of the approved project baseline. (Out of scope items should not be included on the punch list.) The project manager is responsible to complete the work that is represented by the punch list items. As punch list items are completed, the project manager shall verify completion and shall document the completion on the official project punch list. For projects that use a multiple “functional system” turnover and startup testing approach, a separate punch list shall be prepared and maintained for each defined “functional system.” This punch list is generated or part of the commissioning issues log which may be rolled into the comprehensive punch list at this point.

For formal construction projects, substantial construction completion is achieved as punch list items are completed. Remaining punch list items (if any) become the exception list. The exception list (if there is one) is attached to the construction completion document and are completed following turnover.

16.2.2 Construction Completion Document

Summary construction completion documentation is required for formal construction projects. The project manager is responsible for assuring that a construction completion document is initiated and processed as physical construction and construction/installation acceptance testing approach substantial completion.

If specific items on a formal construction project's punch list cannot be readily closed, yet substantial construction completion has been achieved, then the construction completion document should be initiated and processed with exception list attached. The exception list includes all open official project punch list items (including incomplete acceptance tests) that exist when construction completion is achieved. Like the official project punch list, the exception list is maintained and tracked to closure by the project organization.

16.2.3 Closeout Activities

As physical construction nears completion, closeout activities should be performed. For large formal construction projects, a closeout plan and schedule may be appropriate. This plan may or may not be part of the comprehensive commissioning plan. Typical formal construction project closeout activities include:

- Complete all as-built drawings and specification incorporating all properly approved change notices.
- Complete all as-building to reflect construction.
- Ensure that all nonconformance reports and deficiency reports are properly dispositioned and closed out.
- Assemble, review, and turnover all project drawings, specifications, and records.
- Cease formal project performance reporting.
- Terminate charging to the project. This includes not only terminating labor charges, but also closing out all other project financial matters. Examples include completing all supplier and transportation transactions and changes/

claims, closeout of all procurement and subcontracts and release of liens. The cost account manager(s) initiates and processes forms to close a project's cost account(s).

- Dispose of temporary construction facilities, temporary utility services, and excess construction material. Dispose of all secondary hazardous waste generated during construction.
- Generate required project completion/lessons learned documents and reports.
- Complete and process the construction completion document and the project closure forms.
- Generate the final commissioning report (note that this activity may be extended for up to two years after the project is considered substantially complete).

16.2.4 Operations and Maintenance Training

Operations and maintenance training shall be given to the users operations and maintenance staff for all of the larger and more complex equipment and systems. The commissioning authority, with input from the engineering design and the users maintenance staff shall issue a list of all equipment and systems requiring training. Training details may include, but are not limited to the following:

- A training plan will be developed by the commissioning authority. This may be done by the contractor's test engineer and reviewed/approved by the commissioning authority.
- Training will be done in a classroom setting with field training as required.
- The training may be professionally videotaped for the future use of existing and new maintenance personnel.
- A preset number of indexed video copies may be submitted as part of the closeout package.
- All training materials should be ready and available to the participants.
- A training schedule is developed and approved.
- Operations and maintenance manuals (preferably indexed, tabbed, and bound) are submitted at training or with the closeout package. All warranty information, spare parts lists, and other information are to be included with the O&M manuals.

16.3 Operational Readiness Review and Readiness Assessments

DOE policy is that for the startup of new nuclear facilities and for the restart of existing nuclear facilities that have been shut down, a readiness review process shall be implemented that in all cases demonstrate that it is safe to startup (or restart) the applicable facility. The facility shall be started up (or restarted), only after documented independent reviews of readiness have been conducted and specified approvals have been received. The readiness reviews are not intended to be tools of line management to achieve readiness. Rather, the readiness reviews provide an independent confirmation of readiness to start or restart operations.

16.3.1 Operational Readiness Review (ORR)

A disciplined, systematic, documented, performance-based examination of facilities, equipment, personnel, procedures, and management control systems to ensure that a facility will be operated safely within its approve safety envelope, as defined by the facility safety basis. The ORR scope is defined, based on the specifics of the facility and/or the reason for the shutdown as related to a minimum set of core requirements. A graded approach will be used in defining the depth of the ORR, based on these core requirements.

DOE line management shall determine (and ensure that contractor management determines) if ORRs are required for startup of new nuclear facilities or restart of a nuclear facility. DOE shall conduct (and ensure that contractors conduct) an ORR in accordance with DOE Order 425.1A when an ORR is required.

16.3.2 Readiness Assessment

A review that is conducted to determine a facility's readiness to startup or restart when an ORR is not required or when a contractor's standard procedures for startup are not judged by contractor or DOE management to provide an adequate verification of readiness.

For restarts of nuclear facilities not requiring an ORR, as defined in Order 425.1A, DOE line management shall evaluate (and ensure that contractor management evaluates) the need for performing a Readiness Assessment prior to restart. This includes the startup or restart of program work associated with operating facilities when the new or restarted program work does not require DOE approval of changes to facility limits or requirements as stated in authorization basis documents. When a Readiness Assessment is required, operations offices shall develop procedures and ensure that the contractors use the procedures to gain operations office approval of the startup or restart of nuclear facilities. If a Readiness Assessment is not to be performed, the contractor's standard procedures for startup or restart will be used.

16.3.2.1 Operational Readiness Review Documentation

For Operational Readiness Reviews, DOE line management shall require contractors to prepare the following documents: startup/restart notification reports, plans-of-action, ORR implementation plans, and final reports. DOE line management shall prepare its plans-of-action, and ensure the ORR team leaders prepare ORR implementation plans, and final reports. The resolution of all findings from the ORRs shall be documented and maintained with the plans-of-action, implementation plans, and final reports.

16.3.2.2 Breadth of Operational Readiness Review

DOE line management shall develop (and ensure the contractor develops) the breadth of the ORR and documents it in each plan-of-action. A minimum set of core requirements, shall be addressed when developing the breadth of the ORR. The plan-of-action may reference a timely, independent review that addressed the requirement in a technically satisfactory manner to justify not performing further evaluation of a core requirement, or portion thereof. During conduct of the ORR, the breadth may be expanded by the ORR team, if appropriate.

16.3.2.3 Operational Readiness Review Plans-of-Action, Approval, and Content

The contractor and DOE Operational Readiness Review plans-of-action shall be approved by the startup or restart authorities. DOE line management shall ensure the contractor's plan-of-action specifies the prerequisites for starting the responsible contractor's ORR; the prerequisites shall address each minimum core requirement determined to be applicable when developing the scope of the ORR. The DOE plan-of-action shall specify additional prerequisites, such as certification of readiness to oversee facility operations by Operations Office and Headquarters management. The DOE and contractor plans-of-action shall be provided to EH-2 for review and comment.

16.3.2.4 Operational Readiness Review Teams

DOE line management shall appoint (and ensure that contractor management appoints) ORR teams in accordance with the following qualifications and training requirements:

- Technical knowledge of the area assigned for evaluation, including experience working in the technical area.
- Knowledge of performance-based assessment processes and methods.
- Knowledge of facility-specific information.

The ORR teams shall not include as senior members (including team leader) individuals from offices assigned direct line management responsibility for the work being reviewed; any exceptions require approval of the startup or restart authority. Additionally, no ORR team member should review work for which he or she is directly responsible.

The ORR team leaders shall determine and document qualifications of ORR team members.

16.3.2.5 Criteria and Review Approaches

DOE line management requires that the DOE Operational Readiness Review team determines (and ensures that the contractor's ORR team determines) the criteria and reviews approaches to be used for their review, based on the approved breadth given in their plan-of-action, and documents the criteria and review approaches in their ORR implementation plan.

16.3.2.6 Approve and Use Implementation Plans

DOE line management requires that the DOE Operational Readiness Review team leader approves (and ensures that the contractor's ORR team leader approves) their respective implementation plans and use the implementation plans to conduct their ORRs. DOE line management requires that the DOE implementation plan (and ensures that the contractor's implementation plan) is provided to EH-2 for review and comment.

16.3.2.7 Certification and Verification

The following are prerequisites for starting the DOE Operational Readiness Review:

- DOE line management has received correspondence from the responsible contractor certifying that the facility is ready for startup or restart, and this has been verified by the contractor ORR.
- DOE line management has verified that the contractor's preparations for startup or restart have been completed.
- DOE line management has certified that it meets the DOE plan-of-action that includes, as a minimum, the applicable DOE-specific core requirements.

At the start of the DOE Operational Readiness Review, all actions required for startup or restart shall be complete with the exception of a manageable list of open prestart findings that have a well- defined schedule for closure to allow review of the results of the closure process by the DOE Operational Readiness Review team. In the certification and verification process, DOE operations office line management shall document their actions taken to verify operations office and contractor readiness, including review of closure of contractor ORR findings, assessments of completion of defined prerequisites, and other assessments performed to ascertain readiness. Specific events significant to the startup and restart process that occur prior to the formal commencement of the DOE Operational Readiness Review (e.g., site emergency response drills, integrated equipment testing, etc.) may be reviewed by the DOE Operational Readiness Review team when they are conducted.

16.3.2.8 Final Report

Upon completion of the contractor or DOE Operational Readiness Review, DOE line management shall ensure a final report is prepared and approved by the ORR team leader. The final report shall document the results of the ORR and make a conclusion as to whether startup or restart of the nuclear facility can proceed safely. There shall be a statement in each ORR final report as to whether the facility has established the following: an agreed upon set of requirements to govern safe operations of the facility; this set of requirements has been formalized with DOE through the contract or other enforceable mechanism; these requirements have been appropriately implemented in the facility, or appropriate compensatory measures, formally approved, are in place during the period prior to full implementation; and in the opinion of the ORR team, maintain adequate protection of public health and safety, worker safety, and the environment.

This conclusion shall be based on

- review of the program to document conformance with the agreed upon set of requirements, including a process to address new requirements,
- extensive use of references to the established requirements in the ORR documentation.

Additionally, there shall be a "lessons learned" section of the final report that may relate to design, construction, operation, and decommissioning of similar facilities and future ORR efforts.

The core requirements, in aggregate, address many of the core functions and guiding principles of an Integrated Safety Management System (ISMS). The final report should include a statement regarding the team leader's assessment of the adequacy of the implementation of those functions and principles, already addressed by the ORR at the facility undergoing review.

16.3.3 Specific Recommendations

In addition to the preceding information, some specific recommendations related to performing RA/ORR activities follow.

- Establish the scope of the readiness activity, document and control to avoid "scope creep."
- Contractor ORRs should not start prematurely. Readiness should be achieved before starting the review. ORRs are to verify readiness, not achieve readiness.
- Reduce last minute perturbations by providing the implementation plan early to oversight groups.
- When planning the ORR, include not only the time on site for conducting interviews and observations, but also time to consolidate individual preparation, preparing forms, and analyzing data.
- Early in the project, define the ORR prerequisites and core requirements or core objectives.
- Avoid the temptation to constrain the end date when defining the critical path.
- Site access training, facility walkthroughs, and document reviews are essential for team members to gain the necessary familiarity with the project prior to initiation of the ORR.
- The contractor should provide a complete set of surveillance procedures and authorization basis documents.

- Team members should be dedicated for the duration of the review.
- Partial certification packages cause confusion and added work. Analyze the lines of inquiry prior to assigning responsibility for certification package preparation to assure multiple organizations do not answer the same question.
- Clearly define interfaces between organizations at the beginning of the process to avoid conflict and confusion.
- Secure early management support at the appropriate level to confirm necessary organizational support.
- Facility management must assume responsibility and ownership of the readiness review process and be involved in planning and execution. That is, the readiness review process cannot be the responsibility of the project organization. At this point, a project is simply a resource to assist the facility owner.
- A realistic, resource-loaded schedule must be prepared and maintained.
- The lines-of-inquiry review and approval process should screen and eliminate inapplicable lines of inquiry.
- Lines-of-inquiry should be separated as necessary to preferably apply to a single party.
- Assure lines-of-inquiry are clearly written and specific acceptance criteria are provided.
- If possible, avoid parallel readiness review activities, i.e., owner, DOE.
- All deficiencies, both Findings and Observations, must be documented on a Deficiency Form and described in sufficient detail to assess the impact on readiness. This includes deficiencies corrected "on-the-spot."
- The RA/ORR schedule needs to be established consistent with a firm determination as to when facility turnover will occur.

Practice 17

Assessment, Reviews, and Lessons Learned

17 ASSESSMENTS, REVIEWS, AND LESSONS LEARNED

17.1 OVERVIEW

Assessments and reviews are essential to maintain confidence that project systems, processes, and technical efforts are integrated and coordinated effectively, throughout the Department of Energy (DOE). The process provides knowledge to make necessary decisions and to confirm project accomplishments.

Assessments and reviews provide evaluation of the continuing ability of the project to meet its technical and programmatic commitments. They also provide value-added assistance to the project manager as needed. The evaluation is applied throughout the life cycle of the project and consists of planning and conducting reviews and assessments during the project planning, execution, and closure.

All aspects of the review and assessment process should be subject to continuous improvement through a critical decision feedback process. At each critical decision stage in the process, feedback and continuous improvement should be realized. Feedback information on the adequacy of controls is gathered, opportunities for improving the definition and planning of work are identified and implemented, line and independent oversight is conducted, and, if necessary, regulatory enforcement actions occur.

Quality improvement, management assessment, and independent assessment processes should be included as a part of the project. The Preliminary Safety Analysis Report (PSAR) provides a valuable feedback mechanism to the design process through the activity of developing a defensible safety case, as well as through DOE line management and project independent reviews. In addition, an integrated team approach permits the feedback and continuous improvement processes to be functioning both at the formal and informal levels.

All reviews and assessments should be based on a tailored approach considering project-specific attributes, review/decision objectives, and project size. These reviews and assessments form a valuable body of knowledge for future projects and therefore should form the documented foundation for the lessons learned report.

The lessons learned process provides useful information that can be employed by DOE for current and future project teams. They are derived from assessment activities, directed action items, jeopardy items, issues, concerns, and corrective actions.

17.2 Purpose

The purpose of evaluation during the planning phase is to help to ensure that programs and projects support the mission goals and strategic plans. Evaluations also help establish that a project can be successfully performed within allocated resources and applicable constraints**.** Evaluation supports the process by developing recommendations and the supporting data necessary to arrive at decisions either to proceed or not to proceed with subsequent portions of project life cycles.

Evaluations during the execution phase helps to ensure that projects are being successfully executed according to plans and to also provide recommendations for improving the scope, cost, and schedule performance of the project. Evaluations should start during the planning phase and continue through the implementation phase.

Lessons learned provide managers with the opportunity to review summary documentation of previous issues and their mitigation efforts, and to incorporate that experience into similar projects.

17.3 Application

Providing a consistent review and assessment process at each critical decision point ensures adequate control of resources in meeting project objectives. Documenting these assessments provides the value-added benefit of including the lessons learned in the project and agency body of knowledge.

Reviews are essential for the project manager to maintain confidence that project systems, processes, and technical efforts are integrated and effectively coordinated. Reviews also help ensure that the project is progressing at an effective and acceptable rate.

Each project has phases through which it evolves. A clear understanding of these phases permits better control and use of resources in achieving goals. Regardless of size and complexity differences, projects consist of preconceptual activities, a conceptual phase, an execution phase, acceptance, and turnover. The following sections describe the purpose of reviews, the governing body, and the various decision points of the critical decision process.

17.3.1 Energy Systems Acquisition Advisory Board (ESAAB)

The ESAABs serve as both advisors to their respective DOE management levels, and as change boards for Level-0 change requests. The functions and membership of these boards is discussed in the following paragraphs.

- *MS Project ESAABs.* The ESAAB advises the SAE in making MS project CDs, Level-0 baseline changes, and site selections for facilities for new sites. The ESAAB meets once every two months, or at the call of the SAE. ESAAB membership includes the SAE as chair; the Under Secretaries; the General Counsel; the Chief Financial Officer; the Director of OECM; the Assistant Secretary for Environment, Safety and Health; the Assistant Secretary for Environmental Management; the Deputy Administrator for Defense Programs; the Director for Office of Science; and the Director of Procurement and Assistance Management. The Deputy Secretary may designate other PSOs or functional staff as board members, as needed. The ESAAB Secretariat resides in OECM and provides administrative and analytical support and recommendations to the ESAAB.
- *Other Project ESAABs.* Each appropriate PSO appoints an ESAAB-equivalent board for advising on actions regarding those projects within the PSO office that are not MS projects. The PSO serves as AE for these projects and as chair of the ESAAB-equivalent board. The ESAAB-equivalent board replicates and conducts the same functions as those performed by the corporate ESAAB. Members may be selected from within the PSO's office or from other Headquarters functions having departmental responsibility. At least one member is from a different PSO office and is designated by the contributing PSO. OECM provides a member of each ESAAB-equivalent board for projects $100M and greater. Each PSO provides the composition of its ESAAB-equivalent board to OECM.
- *Delegated Other Project ESAABs.* The PSO may delegate equivalent AE functions, including decision approvals, for those other projects below $100M to an SES program manager or an operations/field office manager. For those delegated other projects less than $20M, the program manager or operations/field office manager may further delegate equivalent AE functions to a direct reporting SES subordinate. Figure 17-2 provides an overview of the allowable AE delegations. The AE so designated establishes and chairs an ESAAB-equivalent board, notifies OECM of its composition, invites OECM to all board meetings, and provides all agendas and minutes to OECM and the appropriate PSO project management support office. However, OECM is not a board member.

Table 17.1

ESAAB/ESAASB
Review and Assessment Checklist

Program________________ **Project**________________ **Date**________________

CD-0 CRITERIA

- ▶ Have the program's strategic goals and objectives been addressed? YES ❑ NO ❑
- ▶ Are the projects objectives, requirements, priorities, and constraints documented? YES ❑ NO ❑
- ▶ Has a Risk Management Plan associated with the project been identified, analyzed, and determined to be either avoidable or manageable? YES ❑ NO ❑
- ▶ Has the Mission Need Document and preproject planning activities been completed? YES ❑ NO ❑
- ▶ Have all issues been identified, resolved, and documented? YES ❑ NO ❑

CD-1 CRITERIA

- ▶ Is the risk identification and analysis complete? YES ❑ NO ❑
- ▶ Is the conceptual design report complete? YES ❑ NO ❑
- ▶ Has the Acquisition Plan, including all its elements, been completed? YES ❑ NO ❑
- ▶ Has the preliminary project execution plan, including baseline range and documents, been submitted for SAE/AE approval? YES ❑ NO ❑
- ▶ Have validated project data sheets for design been completed? YES ❑ NO ❑
- ▶ Have all issues been addressed, resolved, and documented? YES ❑ NO ❑

CD-2 CRITERIA

- ▶ Are project engineering and design (PED) funds available for use for Title I and Title II for the project? YES ❑ NO ❑
- ▶ Has the contractor's performance measurement system been reviewed and validated? YES ❑ NO ❑
- ▶ Has the independent cost estimate been completed and verified? YES ❑ NO ❑

- ► Has a Preliminary Safety Analysis report been completed? YES ❑ NO ❑
- ► Has a National Environmental Policy Act, and Record of Decision been documented? YES ❑ NO ❑
- ► Have the project plan and performance baseline been updated? YES ❑ NO ❑
- ► Have the project construction data sheets been completed? YES ❑ NO ❑
- ► Have all issues been resolved and documented? YES ❑ NO ❑

CD-3 CRITERIA

- ► Has the project been included in the budget submittal process? YES ❑ NO ❑
- ► Has the project plan and performance baseline been finalized? YES ❑ NO ❑
- ► Has Title II design or procurement activities been initiated? YES ❑ NO ❑
- ► Has the program office verified that this project supports the Mission need? YES ❑ NO ❑
- ► Have all issues and or jeopardy items been identified, addressed, and documented? YES ❑ NO ❑

CD-4 CRITERIA

- ► Have all activities been executed and completed, including construction? YES ❑ NO ❑
- ► Have the operational readiness review and acceptance report been completed? YES ❑ NO ❑
- ► Has the safety documentation been completed and approved? YES ❑ NO ❑
- ► Has the project closeout report and its supporting documentation been completed? YES ❑ NO ❑
- ► Have all issues been closed out and documented? YES ❑ NO ❑

Project Type	Critical Decision Authority	Threshold	Typical Project Requirements	Acquisition Executive Delegation Allowed
Major System Projects	Secretarial Acquisition Executive	$400M	Quarterly review by PSO Performance Baseline External Independent Review (EIR) Execution Readiness EIR Energy System Acquisition Advisory Board Earned Value Management System reporting required	
Other Projects	Program Secretarial Officer (Acquisition Officer) or Deputy Administrator for NNSA	$100M	Quarterly review by PSO Performance Baseline EIR Execution Readiness Independent Project Review Energy System Acquisition Advisory Board - equivalent Earned Value Management System reporting required	
		$20M	Quarterly review by Program Secretarial Officer or delegate Performance Baseline EIR Execution Readiness Independent Project Review Energy System Acquisition Advisory Board - equivalent Earned Value Management System reporting required	To a Senior Executive Service program manager or operations/ field office manager
		$5M	Quarterly review by Program Secretarial Officer or delegate Performance Baseline EIR Execution Readiness Independent Project Review Energy System Acquisition Advisory Board - equivalent Earned Value Management System reporting NOT required	To a Senior Executive Service direct reporting subordinate of the operations/ field office manager

Figure 17-2. Decision Authority Thresholds

17.3.2 DOE Data Repository

The DOE data repository, maintained by OECM, will provide project management reporting that includes scope, cost, and schedule performance. Headquarters and other major milestone information will be included. The repository will contain a review and assessment checklist (Figure 17-1) for all projects presented to the ESAAB Boards, noting their progress through the critical decision phases. Data is preserved throughout the life cycle of each project proposed and approved. In addition, the repository will contain information regarding issues and jeopardy management items and identify corrective actions. The Issue/Action Item and

Jeopardy Form is designed to accommodate either general issues or specific action items. It is also used for jeopardy issues that may require escalation to higher levels of management. The Issues/Jeopardy tracking log is maintained by each project to track all issues or actions originating from an ESAAB, or from agency or management requests. These documents become an integral part of the "Lessons Learned" file that will be available for evaluation, application on future projects. The project manager will coordinate updates from the field to OECM on a monthly and/or quarterly basis.

17.3.3 Mission/Program Documentation Review and Assessment

The program offices, in partnership with the originating office, submits the Justification of Mission Need and the preconceptual planning documentation to the Deputy Secretary of Energy and his review board (ESAAB) for review and assessment. Prior to the submission of the mission need statement for ESAAB approval, a mission need independent project review will be performed to assure that the mission is credible, justifiable, alternative solutions have been considered, and that the mission need statement is ready to proceed for consideration. When submitted, the documentation should contain short, qualitative information with a primary focus on mission needs. The Deputy Secretary of Energy may approve the mission need documents, approve mission need (CD-0), and the funding request, or they request modification or terminate further project efforts. Approval of CD-0 confirms that the proposed project supports the DOE mission, initiates "formal" start of the project, and authorizes development of the conceptual design and supporting studies to adequately define the project. Documentation supporting the decision should include a preliminary analysis of risk, including technical, schedule, and cost, together with the potential impact on Departmental resources. The preliminary analysis serves to identify issues and opportunities to be addressed during the conceptual phase.

For projects explicitly directed and initiated by Executive Order or a Congressional Act and executed in accordance with Federal Facility Agreements, Tri-Party Agreements, or Presidential or Secretarial Announcement, the direction or edict serves as the mission need critical decision CD-0.

17.3.4 Conceptual Phase Review and Assessment

Conceptual design is the initial formal project phase. Products developed during conceptual design for review and assessment include Acquisition Plan, Conceptual Design Report, Project Execution Plans baseline ranges, Project Data Sheet for design, verification of mission need and Preliminary Hazard Analysis Report. All details associated with the conceptual phase are the responsibility of the Program Office and the originating field office sponsor. The conceptual phase also marks the organization of the Integrated Project Team (IPT) with the Federal Design Manager, the Federal Project Manager and the DOE Field Office, the Contractor Project Managers, and others as designated by the Federal Project Manager.

For all projects, the appropriate AE conducts a quarterly project performance review with the Federal project manager and staff. The contractor may participate in this review as appropriate. For MS projects, the schedule and agenda are coordinated with OECM, and OECM is invited to participate with the PSO in the review. Quarterly performance reviews for other projects with TPCs less than $100M may be delegated to a program manager or operations/field office manager. The contractor may participate in this review as appropriate. OECM is invited to participate in all performance reviews for projects with a TPC over $5M.

17.3.5 Preliminary Design Phase Review and Assessment

The conceptual design phase review and assessment is performed to verify that sufficient progress has been achieved, level of information has been developed, and requirements have been satisfied to allow the expenditure of PSD funds for project design. During conceptual design, the project manager ensures completion and submittal of the Project Data Sheet for construction, National Environmental Policy Act documentation, Preliminary Safety Analysis Report, and Final Project Execution Plan, including the performance baselines. A review of the responsible contractor's project management system, and preparation of an independent cost estimate are also completed to ensure compliance and validation of data.

For projects with a TPC of $5M or greater, an External Independent Review (EIR) may be initiated in response to an external requirement. The Deputy Secretary or the Program Office may request the review with the Office of Engineering and Construction Management (OECM) who arrange for the EIR.

With confirmation of all aspects of the preliminary design phase review and assessment completed, Approve Performance Baseline, CD-2, is approved. OECM updates and records the data in the DOE Repository.

For environmental projects, pertinent data and baselines developed by the field offices and included in the Initial Paths to Closure document will be considered as "Approved for Use" by the Office of Environmental Management.

17.3.6 Final Design and Construction Review and Assessment

With approvals by the appropriate ESAAB to begin final design and project construction, final document updates occur. These include the Project Execution Plan and performance baseline, verification of mission need, safety documentation, and design and procurement packages to the degree appropriate to initiate construction. Construction, in this sense, is a generic term that may refer to engineering development, physical construction, or remedial actions, etc. A CD-3 report also requires the performance of an Execution Readiness Internal Review. The review initiates the request for budget and congressional authorization and appropriation. Critical Decision (CD-3) is approved after confirmation of completion and verification of documents listed above, and the expenditure of funds has been documented. All data reviewed by the board is documented in the DOE repository including "lessons learned" for future potential evaluation.

17.3.7 Project Closeout/Operations Review and Assessment

Prior to project closeout or start of operation, the cognizant project manager will coordinate acceptance/completion documentation to support Critical Decision (CD-4). These documents include the operational readiness review and acceptance report, the Final Safety Analysis Report, and the project transition-to-operations report. Not all projects will undergo transition activities, but may proceed directly to closeout as prescribed by project planning documentation. In this case, a final project closeout report is completed and submitted for review by the ESAAB. Verification of the closeout plan will include the following:

- Roles, responsibility, and authority of the personnel for safe closeout of the project
- Alternative use studies or approvals
- Decommissioning planning, if required
- Closeout approval
- Permits, licenses, and/or other environmental documentation
- Relocation of resources

- Post-project reviews
- Termination or closeout of contracts
- Lessons learned
- Submission of final closeout reporting and any adjustment to obligations and costs.

For projects transitioning to a user, the user and project organizations will perform tests and evaluations to ensure that the project, as designed and built, can be safely operated and meets project mission requirements. Transition of the project to the user concludes with the final acceptance of the facility by the user organization, and is reported to the ESAAB for inclusion by OECM in the DOE repository.

17.4 Independent Reviews

Credible and independent reviews of each project is an expectation of Congress, OMB, local stakeholders, Tribal Nations, and DOE. Headquarters program offices, operations/field offices and the project manager will conduct periodic onsite reviews and assessments of project status throughout project development and execution, as well as, review and analyze project reporting. Reviews will be conducted to assure continuing progress, appropriate planning and development, effective use of funds, mission need, etc. An independent review is conducted by a non-proponent of the project. It may be a science-based or engineering-oriented peer review, a review of the project management structure and interrelationships between key organizational components, a review targeted to a specific issue such as cost or budget, a review covering safety, or a combination thereof. Independent reviews may be combined for efficiency, as appropriate. The completion of a rigorous independent review should reduce the need to perform additional resource-consuming audits and reviews by other organizations.

17.4.1 External Independent Reviews (EIR)

An EIR is conducted by reviewers outside the department. OECM will select an appropriate contracting agency to contract for such reviews, excluding the M&O/ M&I contractors. The actual selection of reviewers, contract management and contact with the contracting officer, and dialogue with the EIR contractor on matters pertaining to the contract are the sole purview of OECM.

All EIRs are managed by OECM and documented in the data repository. The following components are planned and coordinated with the appropriate line manager:

- Specific review scope and objectives
- Organizations/personnel to be reviewed
- Evaluate identities of reviewing organization and individuals
- Select an appropriate (nontypical) review team
- Risk area (to be reviewed at greater levels of detail)

The PSO's project management support office provides coordination for the EIR contractor on site, resolves issues of schedule and access while on site, gathers and provides requested and proffered information to the reviewer, and responds to the reviewer on errors of fact or needed clarification. The project management support office does not provide direction to the reviewer as to the content of the reviewer's report.

Line management, including the Deputy Secretary, PSO, or a program or project organization within the PSO may request an EIR. EIRs also may be initiated in response to an external requirement. However, reviews, studies, or investigations conducted by the General Accounting Office or the Office of the Inspector General are not considered EIRs for DOE purposes.

A tailored approach should be applied in determining the quality and level of detail to be reviewed. Simpler areas that offer low risk of project impact should receive less scrutiny than high-risk areas, those potential costly areas, or areas on which problems seem to be developing. External technical reviews are used to determine if complex issues exist, and for assistance in the resolution of such issues. If a design is new, untried, and unproven, and no standards against which judgments regarding viability can be made, a review by appropriately trained and knowledgeable experts is in order. Technical reviews include reviews of the contractor's project control system.

17.4.2 Independent Project Reviews (IPRs)

An IPR is conducted by reviewers within the department. The Deputy Secretary or SAE, or the PSO and the operations/field office manager and program managers and Federal project managers, may authorize or conduct IPRs as required. The PSO or operations/field office manager, as part of the project management oversight process, may request IPRs through the project management support office for any project, including MS projects. Irrespective of the organizational level initiating an IPR, the PSO or operations/field office manager notifies OECM of its intent to conduct such a review, and OECM is included as an invited observer for all planned reviews. OECM coordinates the extent of participation on a case-by-case basis with the appropriate organization. Committee members of an IPR team are not drawn from the responsible program office within a program secretarial organization, related contractors from the project office, or a related funding program. Reviews may use laboratory, contractor, university, or other expertise from organizations not directly funded by or related to the program/project office being reviewed.

Decision Point Reviews are documented by OECM during the ESAAB process.

17.4.3 Performance Reviews

For all projects, the appropriate AE conducts a quarterly project performance review with the Federal project manager and staff. The contractor may participate in this review as appropriate. For MS projects, the schedule and agenda are coordinated with OECM, and OECM is invited to participate with the PSO in the review. Quarterly performance reviews for other projects with TPCs less than $100M may be delegated to a program manager or operations/field office manager. The contractor may participate in this review as appropriate. OECM is invited to participate in all performance reviews for projects with a TPC over $5M.

Performance reviews should utilize a tailored approach to project-specific attributes, review/decision objectives, project status, size and complexity.

17.4.4 Independent Cost Estimates (ICEs)

ICEs are used primarily to verify project cost and schedule estimates and support the CD-2 process in establishing project performance baselines. ICEs are part of the Performance Baseline EIR, although, and ICE can be combined with any EIR or IPR for efficiency. ICEs may be requested at other times and for other reasons. OECM functions as DOE’s agent, working through appropriate contracting officers to establish contracts for ICEs. ICEs are documented in formal reports submitted to the SAE/AE by OECM. Each ICE is reconciled with the current program office estimate by the Federal project manager.

17.4.5 Mandatory Independent Reviews

The following reviews shall be conducted on all projects over $5M, as described in the acquisition sequence (see Chapter III, Paragraph 3):

- *Mission Validation IPR.* This is a limited review of the project prior to CD-0. It validates the mission need and the funding request.
- *Performance Baseline EIR.* This is a detailed review of the entire project, including an ICE, prior to CD-2. It verifies the mission need; validates the proposed technical, cost, and schedule baseline; and assesses the overall status of the project management and control system.
- *Execution Readiness EIR or IPR.* This is a general review of the project prior to CD-3 that may range from an abridged review of specific areas within a project to a comprehensive review of the entire project. As a minimum, it verifies the readiness of the project to proceed into construction or remedial action.

17.4.6 Other Project Reviews

A number of opportunities exist throughout the project life cycle to use the review process to implement and enhance project execution. A few examples are given that are fairly standard in use during the evolution of the project, e.g., design reviews, environmental assessments, safety analysis review, operational readiness review, etc. The use of nonadvocate experts to supplement the project staff is an approach that can bring credible industry expertise and resources to bear on the project. This can significantly broaden the review viewpoint.

Reviews are held to determine if a product is correct, will perform its intended functions, and meet established requirements. Reviews are also used to determine the current condition of a project. Reviews are an integral part of the project and should be planned in advance and used to complement the line organization’s responsibilities.

17.5 Lessons Learned

The lessons learned process shall be established to create a strategy that ensures continuous improvement on all projects. The process shall involve DOE and contractor participation.

The intent is to provide effective and enhanced information to assist existing and future projects. To do so, the process must capture information from pertinent reviews throughout the life cycle of each project. Two processes are involved: development and incorporation. Development includes the identification, documentation, validation, and dissemination of lessons learned data. Incorporation includes associating lessons learned outcome to applicable project activities for specific improvement actions.

The process is to produce a coordinated system for performance evaluation and facilitation of improvements. Contractor management and internal assessment is the preferred way to create a continuous improvement environment. This evaluation should use a tailored approach and focus on key activities associated with project goals. Areas with the greatest consequence for failure should receive particular emphasis.

Practice 18

18

Records

18 RECORDS

Completing a project successfully requires that all project participants be continuously provided with timely, thorough, and accurate project information, including participants, activities, decisions, progress baselines, changes, decisions, and end product(s). As a project proceeds through its life cycle, the number of participants and activities grow significantly and the volume of information grows exponentially. The task of satisfactorily managing this information is a major challenge and is essential to project success. This section identifies methods of managing and controlling this information.

In the early stages of a project's life cycle, functions and requirements contained in mission need and conceptual design documentation define end product(s). At this time the number of project participants is small and the task of managing project information is relatively easy. The primary focus is on controlling changes to the functions and requirements, thoroughly evaluating and documenting all changes, and ensuring the rapid and complete dissemination of approved changes to all project participants. This process is usually accomplished by controlling the revision and distribution of the document by its identifying requirement.

18.1 BACKGROUND AND INFORMATION

As a project progresses through its life cycle, functions and requirements are expanded to develop design requirements for the functional and physical configuration of the end product(s). These design requirements, in turn, are expanded to the detail required to design, procure, constructs, checkout, and turnover the end product(s). The number of participants also expands to include designers, vendors, suppliers, constructors, operators, and stakeholders, all often representing different organizations and interests. As a result, the task of managing information becomes very complex. The increased volume of information, number of documents, number of participants, and number of requests for changes all contribute to project complexity.

The key processes to managing this information include receipt, identification, document control, change control, and data management, defined as follows:

- Identification—selection of components of the end product(s) to control and selection of the documents that define the product and these components.
- Document Control—receives, identifies, stores, controls, reproduces, tracks, retrieves, and distributes documents.
- Change Control—provides a systematic method for managing changes to a project and its physical and functional configuration to ensure that all changes are properly identified, assessed, reviewed, approved, implemented, tested, and documented.
- Data Management—ensures that necessary project information and project end product(s) are systematically recorded and disseminated for decision making and other uses. Data management is synonymous with "configuration status accounting" as used in contemporary configuration management literature.

Collectively, the integration of these elements among all project participants is referred to as configuration management. Figure 18-1, Documentation and Data Management in the Project Life Cycle, illustrates the relationship of these elements to the Project Life Cycle.

As illustrated in Figure 18-1, elements of documentation and data management are applicable through all phases of the Project Life Cycle. This requires that Headquarters, field managers, the Federal project manager, and the contractor project manager implement applicable elements of documentation and data management in program and project-related activities using a tailored approach, based on the importance and complexity of the project. These applicable configuration management elements interface with and are further integrated with the activities of contractors and other project participants. Collectively, these activities represent a configuration management program applicable throughout the project life cycle.

18.2 Configuration Management and Baseline Management

At any point in its life cycle, from preconceptual to completion of the execution phase, a project has a configuration. Initially, its configuration is a conceptual arrangement of the parts or elements of the desired end product(s). As the project proceeds through its life cycle, the configuration is defined in greater detail through the design process and documented in specifications and drawings. At

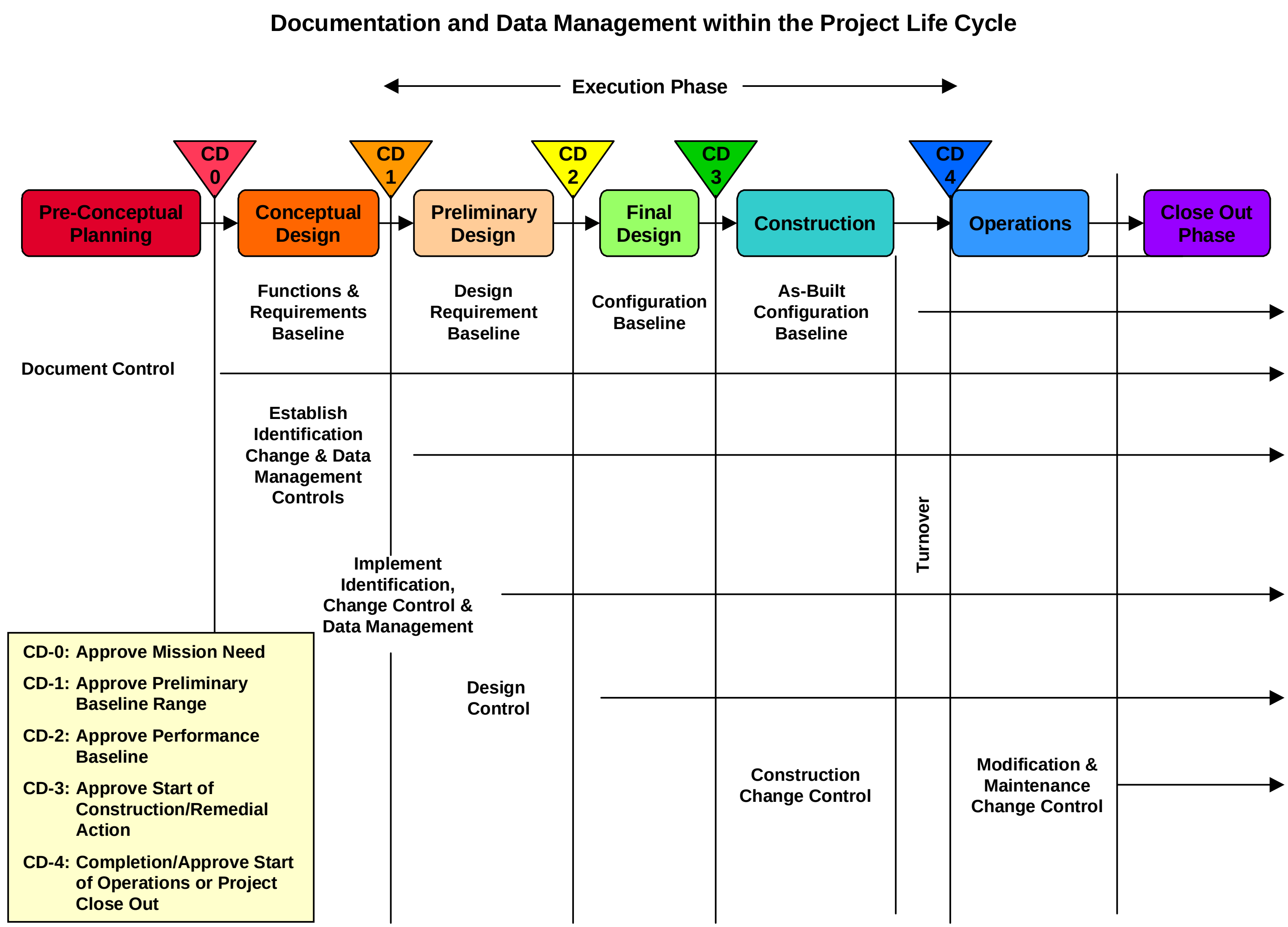

Figure 18-1. Documentation and Data Management in the Project Life Cycle

the end of the life cycle, the configuration becomes an actual physical and functional configuration of the end product(s) and is associated as-built documentation.

Configuration management is used to identify and document the configuration of the end product(s) and control changes to that configuration throughout the project's life cycle.

At selected points in a project's life cycle, the current configuration is established as a reference point or technical baseline. The technical baseline is combined with other project activities (e.g., activities to construct or activities to conduct remedial action) to form a scope baseline. The scope baseline is then used as a basis to develop project schedule and cost baselines. The scope, schedule, and cost baselines serve as a basis for project authorization and management, and as a standard for measurement during project execution. As such, the scope, schedule, and cost baselines are the established plan against which the status of resources and the progress of a project are measured.

Baseline management is used to measure progress and control changes to the scope, schedule, and cost baselines. Configuration management and baseline management are integrated in that the baselines are derived from the configuration and they share a common change control process.

18.3 Process Overview

Figure 18-2, Configuration Management Process Flow Diagram, depicts the overall configuration management process and process elements. In addition to the four key elements of Identification, Document Control, Change Control and Data Management, Figure 18-2 includes the Change Implementation and Review process elements. Specific applicability of these processes to DOE programs and projects is addressed in Practice 7, Baseline Development and Validation, and Practice 14, Critical Design Packages, respectively. A general description of these process elements is provided in the following paragraphs:

18.3.1 Identification

The processes and methods of identifying components of the end product(s) (also referred to as configuration items), as well as the supporting documentation which defines the project and components, are subject to control. The supporting documentation includes the numbers and other identifiers (e.g., document numbers,

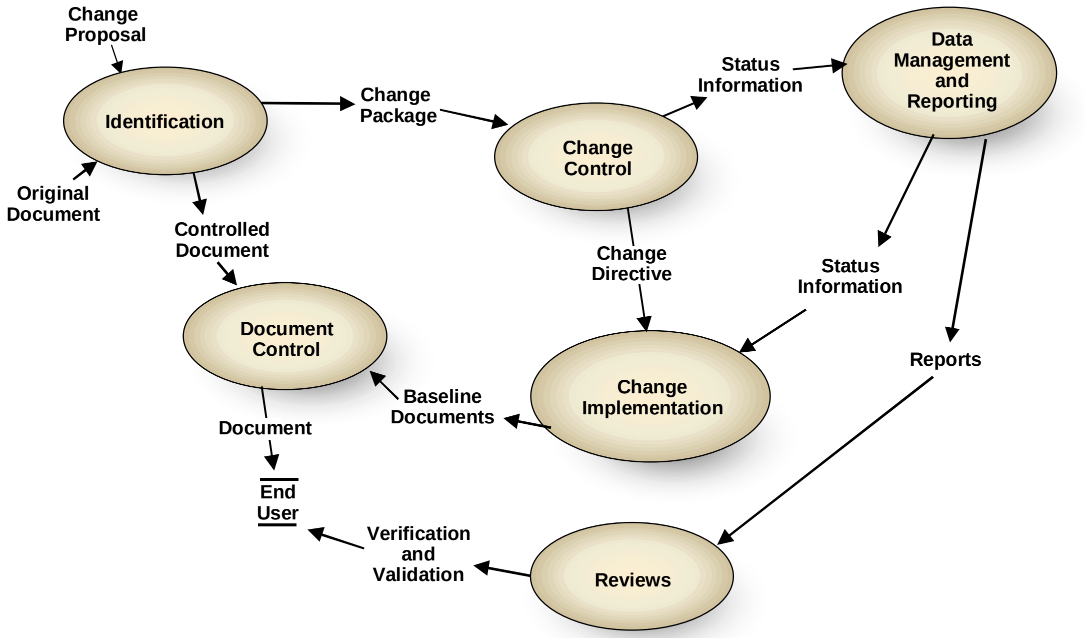

Figure 18-2. Configuration Management Process Flow Diagram

drawing numbers, equipment numbers) assigned to configuration items and documents, and the approved technical documents that identify and define configuration items' functional and physical characteristics, such as specifications, drawings, associated lists, and interface control documents.

18.3.2 Document Control

Document control provides for controlling the distribution of documents and approved changes and retains the master copy in storage for safekeeping. Document control also maintains distribution lists and a master controlled document index. The index includes information such as document title, document number, revision number or date of issue, and the document distribution list. Controlled distribution ensures that recipients of controlled documents are notified of approved changes and that superseded documents are not used for performing work. Document control also provides for record receipt, organization, reproduction, and eventual disposition.

18.3.3 Change Control

The process of managing proposed changes to the configuration items and technical documentation to ensure proposed changes are accurately described, systematically reviewed and evaluated for impact, implemented upon approval, and closed out. The change control process provides for technical scope, schedule, and cost reviews of proposed changes (see Practice 7, Baseline Development and Validation).

18.3.4 Data Management and Reporting

Data management and reporting is the process of recording and reporting the current status of configuration items, technical documentation, and all proposed and approved changes throughout the life cycle of the item. Data management satisfies two needs. The first is to track the implementation of approved change proposals to ensure that all affected documents are updated and that all change directive instructions are followed. This also permits the generation of reports providing the current approved configuration of configured items and their documentation, and pending changes. The second is to create and maintain an audit trail of change proposals through the configuration change control process so that chronological records of changes and reports can be prepared for any configuration item or baseline document.

18.3.5 Reviews

Reviews are the process of verifying that (1) the technical baseline satisfies design requirements, (2) the physical and functional characteristics of configuration items conform to the technical baselines, (3) approved changes have been properly incorporated into the technical baseline, (4) as-built configurations conform to the approved technical baseline, and (5) the entire configuration management program performs in accordance with approved plans and procedures. Reviews are performed periodically to validate that project documentation is properly updated and verify that only current controlled documents are being used to perform work.

18.4 Plans and Procedures

The documentation and data management processes should be controlled by a project configuration management plan. Preparation and use of a configuration management plan should be based on a tailored approach. Each non-DOE organization (e.g., construction) participating in a project shall similarly be required to prepare and maintain a configuration management plan for their portion of the work. Each plan must integrate with the project-level plan. The project-level configuration management plan may be an integrated cohesive assembly of the plans of other participants. The plan should include discussion of how configuration management will be achieved on the project and what items will be so managed. Wherever practical, configuration management activities should be included as steps in procedures for related activities, rather than in standalone configuration management procedures, the steps are integral to the process.

18.5 Scope (Technical) Baseline Identification

The project technical baseline is combined with other project activities to form the scope baseline. The scope baseline is the basis for schedule and cost baselines. The technical baseline defines the physical and functional configuration of the project's end product(s). Baseline management controls the scope, schedule, and cost baselines, and integrates with configuration management that controls the technical baseline. Data management controls information on the project and the configuration of its end product(s).

The technical baseline consists of a top-down set of requirements in which all subsidiary requirements flow down from the requirements above them. Typical DOE technical baselines are defined below.

The titles may vary for a particular program and project and there may be fewer or more baselines. For example, the Tank Waste Remediation System, an EM Strategic System, has two program technical baselines (functional requirements and technical requirements) and five program element/project baselines: design requirements, design configuration, as-built configuration, operational, and decontamination. A minimum set of technical baselines would be those required to support scope, schedule, and cost baseline critical decision submittals.

The relationship of these baselines to the Project Life Cycle is shown in Figure 18-1. A recommended set of documents that should be included in each baseline is shown in Table 18-1, Typical Technical Baseline Documents.

18.5.1 Functions and Requirements Baseline

The initial baseline for projects is developed during the conceptual phase and supports the Approval of Preliminary Baseline Range Critical Decision. It establishes the functions and technical requirements of DOE programs and projects. At this stage of a project, the configuration represented by the baseline is conceptual with nothing designed or built. The functions and requirements baseline is generally developed as follows:

- The DOE mission and objectives are defined.
- Functions of the DOE programs are defined.

Table 18-1. Typical Scope (Technical) Baseline Documents

FUNCTIONS AND REQUIREMENTS BASELINE
▸ Strategic Plans ▸ Program Plans ▸ Justification of Mission Need ▸ Conceptual Design Reports ▸ Project Execution Plans ▸ Interface Control Documents
DESIGN REQUIREMENTS BASELINE
▸ Design Criteria ▸ Preliminary Safety Analysis Reports ▸ System Requirements ▸ Conceptual Design ▸ Preliminary Design ▸ Interface Control Documents
CONFIGURATION BASELINE
▸ Final Safety Analysis Report ▸ Final Design ▸ Operational Safety Requirements ▸ Specifications ▸ Drawings

- Quality Assurance Procedures
- Test Procedures
- Operating and Maintenance Procedures
- Procurement Documents
- Work Control Packages
- Operating and Maintenance Manuals
- Construction Procedures

18.5.2 Design Requirements Baseline

For complex projects, the design portion of the execution phase is often split into preliminary design and final design. Through the preparation of preliminary planning and engineering studies, preliminary design translates the functions and requirements from the conceptual phase into preliminary drawings and outline specifications, life cycle cost analysis, preliminary cost estimates and scheduling for project completion. Preliminary design identifies long-lead procurement items and provides analysis of risks associated with continued project development. At this stage of a project, the configuration defined by the preliminary drawings and outline specifications is represented by the design requirements baseline with the following content:

1. The physical systems for each project or facility are identified.
2. The boundaries and interfaces for each physical system are identified.
3. The major components for the physical systems are identified and defined.
4. The functions and requirements, and performance criteria and constraints established in the conceptual phase are allocated to the respective physical systems and major components.

18.5.3 Configuration Baseline

The configuration baseline represents the output of the detailed design portion of the execution phase and supports the Approve Start Construction Critical Decision. The functions and requirements from the conceptual phase and the design requirements from preliminary design, as applicable, are expanded to include the detail required to construct the systems and components of the end product(s).

The configuration of the project is defined by the design output documents that include procurement and construction specifications, drawings, test procedures, and operating and maintenance information.

18.5.4 As-Built Configuration Baseline

At completion of the construction portion of the execution phase, the detailed design documents established in the configuration baseline are used to establish the as-built configuration baseline as follows:

1. All changes to the configuration baseline during construction are approved and reflected in the as-built configuration baseline.
2. All changes to the configuration baseline during the operations phase after system turnover are approved and reflected in the as-built configuration baseline.
3. Configuration baseline documents with the approved updates are incorporated to reflect the physical configuration.
4. Interfaces of the DOE activities, programs, and projects with other facilities, programs, and projects are identified.

18.5.5 Establishment of Baselines

Development of baselines for DOE programs, projects, and operating facilities should adhere to the following management concepts set forth by DOE O 413.1:

- Identification, documentation, and approval of basic requirements.
- Specification of a systematic process for development of baselines.
- Formal identification and approval of baselines.
- Specification of allowed variances from the approved baselines.
- Regular reporting and assessment of status against the approved baselines.
- Corrective management action (that may include baseline revision) in the event a variance exceeds a prescribed threshold.

18.5.6 Records Identification

Each project record shall be identified with a unique identifier (e.g., drawing, component, or equipment number). The unique identifier is needed to ensure consistency, retrievability, and traceability of technical and baseline documentation for configuration items. In addition, each project shall develop and maintain current lists of project products (e.g., drawings, specifications, equipment, instrumentation, lines, valves, etc.) Documentation associated with each physical product (pumps, valves) shall be traceable to that item through the unique item identification number. For DOE, the configuration identification guidelines apply specifically to

- physical items (e.g., facilities, structures, systems, and components).
- software.
- site characteristic data and samples.
- waste packaging.
- documentation (including supporting analysis and data).

The level of identification required varies with the importance of the configuration item and the indentured level from which documentation needs to be retrieved. Structures, systems, and components important to safety require a more detailed identification than other nonsafety items. This ensures traceability of requirements throughout the life of the project, program, or operating facility.

18.5.7 Traceability

Configuration management shall require traceability of technical baseline requirements and data through all phases of DOE programs and projects. Technical baseline documents should establish traceability of requirements through all levels of documentation and to the configured items. Regulatory and other design basis requirements depicted in documents that describe configured items should be readily traceable to their origin through design requirements documents, etc.

The baselining process allocates technical requirements to subsequent levels of detail. Throughout the design, construction, and turnover phases, materials and components should be traceable to their application and physical location. Traceability of technical requirements should be established by uniquely identifying configured items and in the associated documentation. Data management systems should be used to cross-reference the appropriate documents to configured items.

18.5.8 Software Configuration Management

The configuration management program must require that essential computer software and associated documentation be identified and controlled. Software designated to be controlled should be uniquely identified and established as part of the technical baseline. Software that should be included in the configuration management program includes

- operations and process control.
- protection systems.
- engineering development, design analyses, evaluation, and assessment.
- mathematical models.
- database or document indexes when used as a controlled source of information.
- computer-aided design/manufacturing/engineering (CAD/CAM/CAE).

18.5.9 Interface Control

The functions, requirements, and physical characteristics of the end product(s) at common boundaries among project participants must be identified, documented, and controlled. For complex projects, interface control working groups should be established to identify, document, and monitor interfaces. Interface control documents shall be used to define interfaces, interface responsibilities, and interface requirements in terms of functions, requirements, and physical characteristics, as appropriate, and interface constraints and assumptions. For changes in functions, requirements, and physical characteristics between two configuration items controlled by different organizations, the interface control documents should include interface control drawings and should be baselined, approved, and controlled.

18.5.10 Data Management

Computerized information applications shall be used to collect, store, and maintain configuration management technical baseline information and changes thereto. When used, the design, development, implementation, and use of these applications should be subject to the guidelines of the configuration management program.

New facilities should develop a Master Equipment List (MEL) database during design and construction. This list should contain structures, systems, and components selected by the project manager and the contractor based upon safety grades assigned to these systems. As a minimum, the list should have the following features:

1. All structures, systems, and components should be classified (where applicable) by engineering system, start-up system, operating system, safety class, hazard category, instrument loop number, piping line number, circuit number, plant location, applicable Work Breakdown Structure (WBS) element, or any other category of interest to the users of the MEL.

2. Lists should be extractable by category. For example, a list of all Safety Class 1 items.

3. Each component should reference its unique identification number, engineering drawing, or specification number and other related documents. For example, applicable Safety Analysis Reports (SARs), interface control document, spare parts list, and test procedure.

4. Operating and maintenance procedures should be cross-referenced to their associated structures, systems, components, and operating systems as applicable.

5. Each existing facility classified as a Hazards Category Class 3 or higher should develop a Safety Equipment List (SEL) for Safety Class 1 equipment only. The SEL should contain the data specified above and should be a subset of the MEL.

18.5.11 Reviews/Assessments

Review and assessments should be performed to measure the effectiveness of the configuration management process and consistency between the project physical system and the documentation that represents that system. Contractor reviews, assessments, surveillance, results and corrective actions must be documented and tracked to closure.

- *Programmatic Assessment.* Programmatic assessments should determine the acceptability of the configuration management process and implementation of the requirements contained in project execution and planning documentation. Initially, assessments should identify procedural weaknesses and necessary corrective actions. Subsequent assessments should determine the effectiveness of corrective actions and continue to monitor and improve the configuration management process.
- *Physical Configuration Assessments.* Periodic physical configuration assessments should determine the consistency between the documented technical baseline and the actual physical configuration. Discrepancies should be analyzed and appropriate corrective action taken to resolve them. An annual schedule for physical configuration assessments should be prepared by the contractor and submitted as an integral part of work planning documentation.

18.6 Document Control for Configuration Management

Documents must be controlled and distributed to ensure that only the applicable approved version is available for use, and to ensure prompt communication of changes. The effective control of documents is essential to the success of the configuration management program because the documents are the vehicles used to communicate information to affected organizations. The configuration management program should ensure processes (based on a tailored approach) are in place to assure that

- controlled documents are uniquely identified and identification systems are proceduralized.
- controlled documents are reviewed, approved, changed, and released through the change control processes.
- controlled documents are kept current by controlled distribution, including a receipt acknowledgment process.
- users needing controlled copies have ready access to current revisions of controlled copies.
- databases providing revision-level information are controlled and maintained current.

- record retrieval systems are in-place that allow timely retrieval of historic documents and the cross-referenced material in those documents.
- effective dates are established for controlled documents that allow for changes to impacted documents and related training.

All technical baseline documents should be issued as controlled documents. On approval, these documents should be entered in the appropriate controlled document list.

18.6.1 Roles

Each project organization has specific roles and responsibilities related to documentation and data management:

- Project Manager
  - Approve the standard distribution list for the controlled documents within their areas of responsibility.
  - Generate and distribute a controlled document list.
  - Ensure only current revisions of controlled documents are used in performing quality-related work activities.
- Document Originating Organization
  - Ensure controlled documents released for distribution have been appropriately reviewed for technical adequacy and approved.
  - Ensure effective dates for controlled documents are established prior to release for distribution.
- Document Distributing Organization
  - Ensure controlled documents are distributed in accordance with approved procedures.

18.6.2 Guidelines

Organizations that generate project documents shall define the process for the preparation, format, review, approval, revision, and verification of the technical adequacy of those documents:

- *Document Numbering.*
  - — Each controlled document must be identified by a unique number that appears on all pages of the document. The original identification number must be retained throughout all changes to and revisions of the document. Should a document be canceled, that unique number shall not be reused.
  - — The current revision number of each controlled document must appear on all changed pages issued since the initial issuance or last complete revision.
  - — Pages within a controlled document must be numbered in a manner that allows page accountability.
- *Control Identification.* Controlled documents must be cleanly identified as controlled by use of colored paper or a color-identified stamp indicating a "controlled" status. Black must not be an acceptable color identification for the control stamp. Without this control identification, documents shall be considered uncontrolled.
- *Controlled Documents List*. A controlled documents list must be prepared and maintained that identifies controlled documents originated by their organizations and lists the individual document title and number, the current revision number and date, effective date, and originating and distributing organizations.
- *Document Revisions.*
  - — Revisions to controlled documents must be reviewed and approved by the same organizations that reviewed and approved the original issue, unless delegated to another qualified organization.
  - — Inclusion of revision/change information must be made part of the document by one of the following methods:
    - • Inclusion of a revision/change record as part of the transmittal package.
    - • Inclusion of a revision/change log as part of the document
  - — The revision/change information must include the reason for the revision and identify the page(s) revised.
- *Document Review.* Organizations originating controlled documents shall procedurally define the required review and approval cycles. Resolution of review comments, for which resolution is considered mandatory by the responsible organization prior to approval, shall be documented.

- *Document Release.*
  - — Organizations originating controlled documents must be responsible for ensuring controlled documents are legible, reproducible, adequately reviewed and appropriately approved prior to release for distribution. An effective date for the controlled document shall be indicated on the first page of the controlled document, allowing sufficient time for the development/revision of implementing procedures and training as appropriate.
  - — When the revised document is maintained in a manual, an updated table of contents or an index should be prepared which accompanies the revision that is forwarded to the distributing organization.
- *Document Distribution.*
  - — A unique controlled copy number should be assigned to each controlled document listed on the standard distribution list.
  - — A systematic transmittal and receipt acknowledgment process shall be used to control distribution and track receipt of controlled documents. Individually addressed transmittals shall be used to transmit controlled copies of documents to each person on the standard distribution list. The transmittal record shall also contain any necessary instructions, including the deadline for return of the signed transmittal receipt and disposition instructions for superseded documents/pages.
  - — The recipient of each controlled copy must sign and return the transmittal form to the distributing organization by the due date specified and maintain their controlled copy current.
- *Standard Distribution List.* Standard distribution lists must be developed for controlled documents and maintained by the organization distributing controlled documents. Additions to or deletions from the standard distribution lists should be authorized by the organization originating the documents. Controlled distribution shall be limited to avoid the creation of an unduly cumbersome or unmanageable document control system that may ultimately prove self-defeating.
- *Document Use.* The document user is responsible to ensure that only the current revision of controlled documents are used in the conduct of activities. Currency shall be readily verifiable by contacting the distributing organization or referencing the controlled document list.

- *Document Assessment.* At least annually, each distributing organization shall require each controlled copyholder to inventory and verify currency of all controlled copies assigned to that particular copyholder. Random assessments of controlled copies should be made on an as-needed-basis by the distributing organizations to confirm the adequacy of the controlled distribution process.
- *Maintenance of Controlled Copies.* As appropriate, controlled copies of project documents shall be maintained by the responsible project organization.
  - — Master Copy. A master copy is the copy used by distributing organizations for reproduction, distribution, and reference of the current revision. The master copy must not be checked out of the distributing organization's files and access control must be maintained. Only the current revision shall be considered a master copy. Historical, superseded, or obsolete revisions should be retained in the appropriate records systems.
  - — Controlled Copies. Recipients of each controlled copy must maintain the controlled copy current, promptly inform the distributing organization of any changes in physical relocation, position responsibilities, or titles, and, at least annually, assess the accuracy of their controlled copy(ies).

18.7 PROJECT COMMUNICATIONS MANAGEMENT

18.7.1 Information Distribution

Information distribution involves making needed information available to project stakeholders in a timely manner and includes implementing the communications management plan as well as responding to unexpected requests for information.

18.7.1.1 Inputs to Information distribution:

- Work Results
  - — Communications Management Plan
  - — Project Plan
  - — Tools and Techniques for Information Distribution
  - — *Communication Skills.* Communications skills are used to exchange information. The sender is responsible for making the information clear,

unambiguous, and complete so that the receiver can receive it correctly and confirming that it is properly understood. The receiver is responsible for making sure that the information is received in its entirety and understood correctly. Communicating has many dimensions:

A) Written and oral, listening and speaking

B) Internal (within the project) and external (to the customer, the media, the public, etc.)

C) Formal (reports, briefings, etc.) and informal (memos, ad hoc conversations, etc.)

D) Vertical (up and down the organization) and horizontal (with peers).

— *Information Retrieval Systems.* Information can be shared by team members through a variety of methods including manual filing systems, electronic text databases, project management software, and systems that allow access to technical documentation such as engineering drawings.

— *Information Distribution Systems.* Project information may be distributed using a variety of methods including project meetings, hard copy document distribution, shared access to networked electronic databases, fax, electronic mail, voice mail, and video conferencing.

- Outputs from Information Distribution

  — *Project Records.* Project records may include correspondence, memos, reports, and documents describing the project. This information should, to the extent possible and appropriate, be maintained in an organized fashion. Project Team members may often maintain personal records in a project notebook.

18.7.2 Performance Reporting

Performance reporting involves collecting and disseminating performance information in order to provide stakeholders with information about how resources are being used to achieve project objectives. This process includes

- status reporting—describing present project status

- progress reporting—describing what the project team has accomplished
- forecasting—predicting future project status and progress.

Performance reporting should generally provide information on scope, schedule, cost, and quality. Many projects also require information on risk and procurement. Reports may be prepared comprehensively or on an exception basis.

18.7.2.1 Inputs to Performance Reporting

— *Project Execution Plan.* The Project Execution Plan contains the various baselines that will be used to assess project performance.

— *Work Result.* Work results—which deliverables have been fully or partially completed, what costs have been incurred or committed, etc.—are an output of project execution. Work results should be reported within the framework provided by the communications management plan. Accurate, uniform information on work results is essential to useful performance reporting.

— *Other Project Records.* In addition to the Project Execution Plan and the project's work results, other project documents often contain information pertaining to the project context that should be considered when assessing project performance.

18.7.2.2 Tools and Techniques for Performance Reporting

— *Performance Reviews.* Performance reviews are meetings held to assess project status or progress. Performance reviews are typically used in conjunction with one or more of the performance reporting techniques described below:

— *Variance Analysis.* Variance analysis involves comparing actual project results to planned or expected results. Schedule and cost variances are the most frequently analyzed, but variances from the plan in the areas of scope, quality and risk are often of equal or greater importance.

— *Trend Analysis.* Trend analysis involves examining project results over time to determine if performance is improving or deteriorating.

— *Earned Value Analysis.* Earned value analysis in its various forms is the most commonly used method of performance measurement. It integrates scope, cost, and schedule measures to help the project management team assess project performance.

18.7.2.3 Outputs from Performance Reporting

— *Performance Reports.* Performance reports organize and summarize the information gathered and present the results of any analysis. Reports should provide the kinds of information and the level of detail required by various stakeholders as documented in the communications management plan.

  Common formats for performance reports include bar charts (also called Gantt charts), histograms, S-curves, and tables.

— *Change Requests.* Analysis of project performance often generates a request for a change to some aspect of the project. Change requests are handled as described in the various change control processes (e.g., scope change management, schedule control, etc.).

18.7.3 Administrative Closure

The project or phase, after either achieving its objectives or being terminated for other reasons, requires closure. Administrative closure consists of verifying and documenting project results to formalize acceptance of the product or the project by the sponsor, client, or customer. It includes collection of project records, ensuring that they reflect final specifications, analysis of project success, and effectiveness and archiving such information for future use.

Administrative closure activities should not be delayed until project completion. Each phase of the project should be properly closed to ensure important and useful information is not lost.

18.7.3.1 Inputs to Administrative Closure

— *Performance Measurement Documentation.* All documentation produced to record and analyze project performance, including the planning documents that established the framework for performance measurement, must be available for review during administrative closure.

— *Documentation of the Product or the Project.* Documents produced to describe the product of the project (plans, specifications, technical documentation, drawings, electronic files etc.—the terminology varies by application area) must also be available for review during administrative closure.

— *Other Project Records.* All other appropriate project records that aid understanding project initiation, performance, scope, schedule, and cost.

18.7.3.2 Tools and Techniques for Administrative Closure:

— *Project Archives.* A complete set of indexed project records should be prepared for archiving by the appropriate parties. Any project-specific or program-wide historical databases pertinent to the project should be updated. When projects are done under contract or when they involve significant procurement, particular attention must be paid to archiving financial records.

— *Formal Acceptance.* Documentation that the client or sponsor has accepted the product of the project (or phase) should be prepared and distributed.

— *Lessons Learned.* A lessons learned document shall be prepared and issued at the completion of a project. The most effective and efficient approach to this requirement is the preparation and issuance of a routine (weekly) Lessons Learned report throughout the life of a project.

Practice 19

19

Closeout

19 CLOSEOUT

19.1 OVERVIEW

Closeout provides information about project completion, including transition, physical closeout, and financial closeout.

The DOE project transition, closeout, and termination processes should be applied to all projects. The processes described can apply to completed projects, or to a portion of a project that functions independently of other portions of the project. Partial closure of a project can be appropriate and can help the Department maintain more accurate project, financial, and property records.

Closing the project is a time of emotional—and user—satisfaction. However, even when a project is well done, one must recognize that it is really not quite finished. Project closure is the time to take the necessary steps to ensure customer, user, team members and contractors are treated properly so as to close the loop on all loose ends on the project.

Closure can be a quick or protracted time for a project. In the event the project manager is reassigned prior to final project completion, a project closure manager should be designated. If not included in the PEP, a separate plan for demobilizing the work force and dispositioning the physical assets should be prepared and executed. Turnover to the user should be documented and appropriately signed off.

The project manager should maintain the records and correspondence file for project documentation until the contract is officially closed or as long as deemed necessary by project requirements. This system of records (see Practice 18, Records) must be adequate to allow a competent person to respond to claims even though they were not part of the original project team. Closure is an area of concern and must receive sufficient attention to assure it is done in a timely and complete manner. Particular attention should be given to completion reports that provided the basis for fee performance or payments. If deemed appropriate, a third party could provide a review and assessment of the adequacy of closure records prior to demobilizing the project team.

19.2 TRANSITION PLANNING

Moving a project from the execution phase to user acceptance or long-term care status requires that technical and administrative matters be addressed during earlier phases of the project. As early in the execution phase as feasible, the project manager should initiate planning for and development of the documentation necessary for transitioning the project to the user. Planning could include development of operations and maintenance manuals and procedures, preparation of as-built drawings, and the procurement of materials required for initial operation. Planning should be developed in conjunction with the user to encourage complete mutual understanding and agreement. Normally, the project transition plan is prepared by the contractor under the guidance of DOE. Depending on the type of project and the end use of the project deliverables, a transition plan typically:

- Specific roles and responsibilities of DOE, the contractor, and the user. Responsibilities will vary depending on the type of project, but can typically include the following considerations:
  - Operations startup safety
  - Training of user personnel
  - Site support: utilities, security, other support
  - Sustained engineering support
  - Spare parts/components inventory
  - Operational testing
  - Specialized vendor support for unique equipment operations requirements
  - Authority for releasing contractors
- A resource plan addressing the phaseout of personnel whose expertise is not required for transition. However, consideration should be given to obtaining or retaining specialized skills needed for transition, such as startup personnel.
- A comprehensive transition schedule
- Turnover and acceptance procedures
- A list of permits or licenses required for facility use

- Operational testing, which can include:
  - identification of functional or integrated systems tests
  - identification and training of test teams
  - development of accept/reject test criteria
  - a method for documenting test results and resolving failed components or systems.

19.3 PROJECT TURNOVER / ACCEPTANCE

For some projects, an operations phase follows the completion of the project. When, following completion of the construction phase, the project begins transition activities leading to operation, the project manager should maintain responsibility for project functions so that they can address issues that arise concerning the project. The project manager should also work closely with user organizations to complete acceptance testing and startup in accordance with planning documentation developed during the project's execution phase. As previously planned, either the user or project organization will be responsible for performing tests and evaluations to ensure that the project can be safely operated as designed and built.

During transition, the user organization will normally accept beneficial occupancy of the facility and assume ownership of project documentation. Typically, the documentation transferred from the project organization to the user organization would include

- Environmental and safety
- Design basis
- Drawings and specification, including as-built
- Configuration management
- Equipment and operating manuals, project records, and other relevant information.

The user manager or project manager would normally prepare and submit acceptance completion documentation to support CD-4, which occurs before operations begin or decommissioning/remediation phases are complete (see Practice 4, Project Execution Plan). This documentation indicates that technical performance has been demonstrated as acceptable and that no further transition activities are necessary. The acceptance phase concludes with documented acceptance of the project by the user organization. Figure 19-1 depicts the sequence of primary activities/events necessary for project closure.

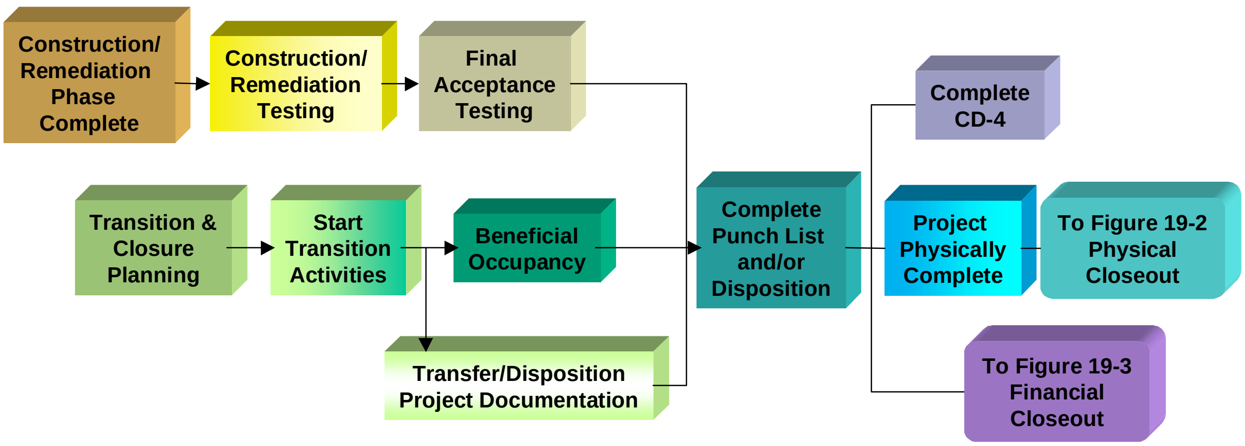

Figure 19-1. Overall Project Transition and Closure Flow

19.4 PROJECT CLOSEOUT

A project is ready for closeout once it has successfully made the transition from the project organization and has been accepted by the user organization.

Project closeout begins at beneficial occupancy or project termination, and is complete after all financial closeout activities are complete. Typically, the contractor will be allowed up to six months on smaller projects and twelve months on larger projects to prepare the Final Cost Report following project completion, CD-4. The Final Cost Report will include total project costs-to-date and estimates for any remaining work that may still be outstanding. The Final Cost Report should also include accruals, and estimates for outstanding claims, if applicable. Timely submission of this report will facilitate removal of completed projects from the financial reporting system. Obligations other than those identified in the Final Cost Report are de-obligated and returned to the chief financial officer.

Project closeout occurs in two primary steps: physical and financial, in that order.

19.5 Physical Closeout

Physical project closeout primarily consists of activities remaining after the user accepts the project. The project manager completes post-acceptance activities and requests project closure approval from DOE. Activities associated with physical project closeout are as follows:

1. When completion criteria are established, preferably in the project execution plan, the project manager must review each criterion and provide a written determination as to satisfactory completion.
2. All turnover punch list items must be reviewed to ensure they have been completed to the satisfaction of the project and the user organization. Any uncompleted punch list items must receive the project manager's immediate attention to facilitate closure. Punch list closure will, in most circumstances, hasten the release of the construction contractor.
3. Excess material and equipment must be identified, retrieved from subcontractors, and dispositioned in accordance with DOE property disposition regulations. Disposing of excess material or equipment can also entail adjustments to capital equipment accounts.
4. All purchase orders should be closed. If a purchase order cannot be closed, the project manager should open a single account to deal with residual outstanding obligations. Outstanding obligations should be included in the Final Cost report.
5. A Project Closure Report (Table 19-1) must be prepared.
6. An Occupancy Checklist (Table 19-2) should be prepared and used to accelerate the transition process.
7. All remaining project control accounts, except those for outstanding obligations, should be closed to assure additional charges are not accepted
8. The project lessons learned report must be completed and provided to the DOE.

The project manager should receive the request for project closure approval with necessary supporting documentation. At that time, the project manager should determine (and may conduct an independent inquiry) that all actions have been satisfactorily completed.

Table 19-2. Project Closure Report

PROJECT CLOSURE REPORT

Project Title:	**Contractor Reference Number:**	**DOE Reference Number:**
Project Purpose and Scope:		
Project Original Baseline Plan	**Completion Cost**	**Completion Date**
Project Final Completion Baseline		
Discussion on Issues/Costs/Technical:		
Key Learning Points and Recommendations:		
Actions Assigned, if any:		
Project Manager: ______________________________		
Report Review, if any **Date** **Signature**		

Table 19-3. Occupancy Checklist

Goal: Ensure that at least the minimum building, life safety, and security conditions exist prior to moving personnel into a new building and to make an informed management decision on whether or not to occupy.

Priority Level 1 = Must be completed prior to occupying the building for life safety, fire protection, security, and other mandatory ES&H requirements.

Priority Level 2 = Must be completed prior to the customer commencing operations.

Priority Level 3 = These items can be completed after the building is occupied and after the customer is operating.

Instructions: The responsible individual will date and initial when each item is functional. Outstanding punchlist items may be corrected later.

Item	System Support	System Description	Priority	Example Concerns	Architectural Inspector	Mechanical Inspector	Electrical Inspector	Customer Rep	Notification Contact	Issues/Concerns and Associated Risk (for assessment)
1	Building	Building Structure	1A	Any structural concerns?	X				CME	
2	Building	Emergency Egress	1A	Paving, concrete walkways in a place for exterior egress routes?	X				Incident Commander	
3	Building	Fire Detection and Alarm	1A	Building fire detection and alarm system installed and operational?			X		Fire Protection Engineer	
4	Building	Fire Response Access	1A	Fire fighting systems in place, including connections, hydrants, and standpipes?		X			Incident Commander	
5	Building	Lighting	1A	Emergency Lighting System installed and operational? Inverters purchased?			X		CME	
6	Building	Lighting	1A	Interior lights operational?			X		CME	
7	Building	Power Distribution	1A	Building power installed, tested and operational?			X		CME	
8	Building	Access Control	1B	Exterior doors rekeyed?	X				Security	
9	Building	Domestic Water	1B	Domestic water system installed, tested, and operational? Lines sanitized?		X			CME	
10	Building	Fencing, Gates	1B	Required security fences, gate in place to support customer operations?	X				Security	
11	Building	Fire Protection	1B	Fire department notified that new building is on system?		X			Incident Commander	
12	Building	Fire Protection	1B	Dedicated telephone line installed, tested and operational?			X		Fire Protection Engineer	
13	Building	Fire Protection	1B	Building fire suppressions system installed and operational?		X			Fire Protection Engineer	
14	Building	Restrooms	1B	Restrooms stocked with supplies and services scheduled to support occupancy?	X				Custodial Services	
15	Building	Sanitary Sewer	1B	Sanitary sewer system installed, tested and operational?		X			CME	
16	Building	Emergency Response	1C	Vehicle access routes available to support response of emergency vehicles?	X				Incident Commander	
17	Building	Fire Protection	1C	Fire extinguishers in place?		X			Incident Commander	
18	Building	Lighting	1C	Exterior lights and parking light operational?			X		CME	
19	Building	Compressed Air	2A	HVAC pneumatic control system installed, tested, and operational?		X			CME	
20	Building	Exhaust System	2A	Fans operational and filters (HEPA) in place?		X			CME	

Once the physical project completion request is approved, the project may begin financial closeout. Figure 19-2 depicts the physical closeout process.

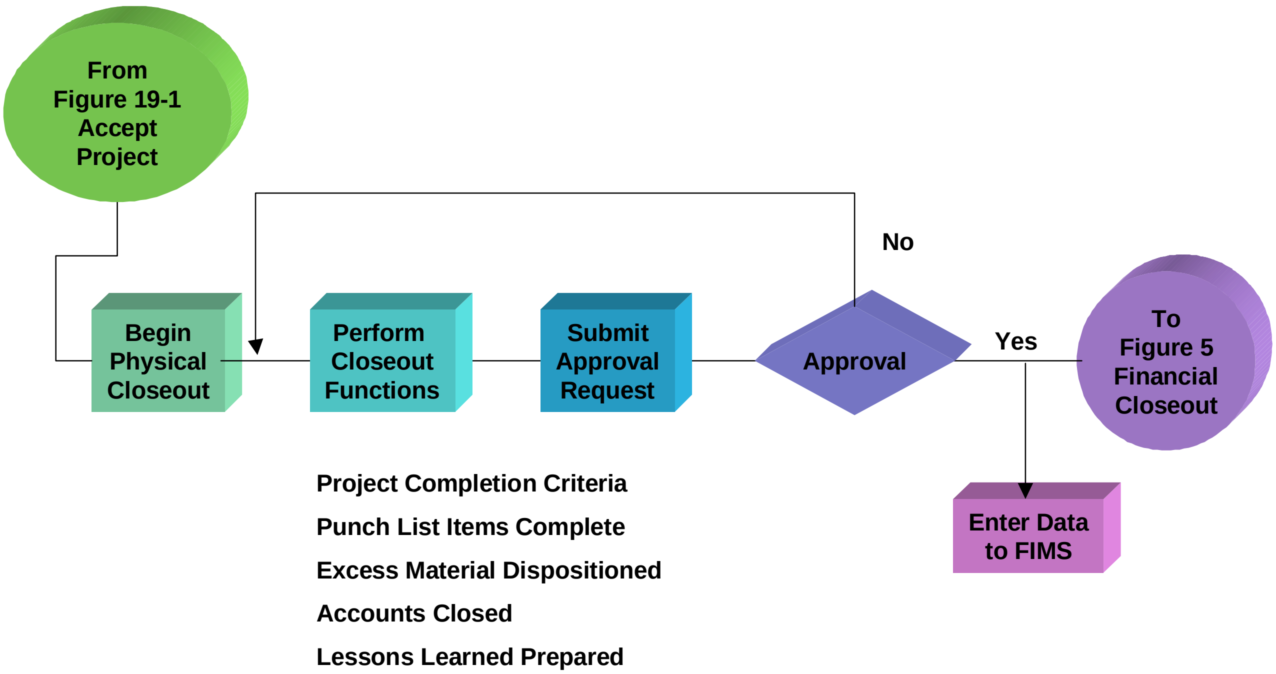

Figure 19-2. Physical Closeout Logic Flow

19.6 Financial Closeout

Once the user organization has beneficially occupied a facility, the project organization may begin preparing for financial closeout Figure 19-3.) Although financial closeout and physical closeout can occur in parallel, financial closeout is finalized only after a successful physical closeout is complete. The timely closing of a project is of paramount interest both to Congress and the Department, each of which has an objective to identify unspent balances and deobligate them for use elsewhere as needed. As described in this section, financial closeout follows two parallel paths that help meet this objective: adjusting the Department's construction and capital asset accounts and preparing the project Final Cost Report (Figure 19-3).

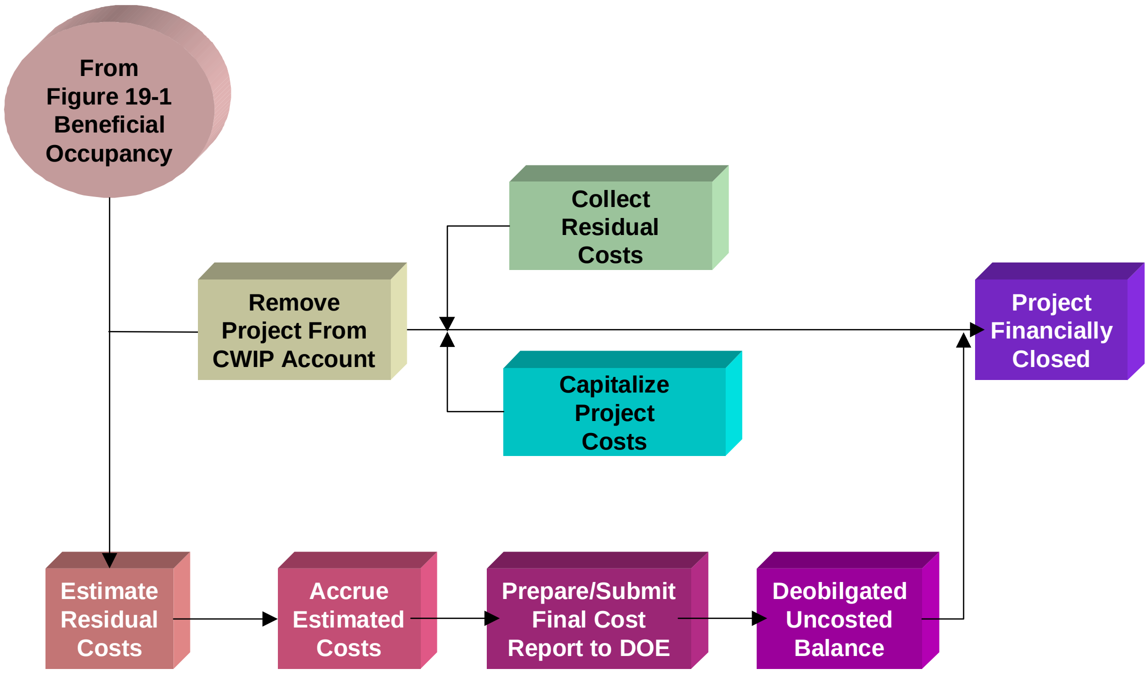

Figure 19-3. Financial Closeout Logic Flow

The DOE uses the Final Cost Report to determine if unspent balances remain. Remaining balances are deobligated through the approved funding program and reported to Headquarters, which ensures a source of funds if the project must be reopened later.

The project manager prepares the Final Cost Report for a project. Preparation of this report can begin once the user organization takes beneficial occupancy. Normally, work on a facility is not completed at beneficial occupancy and the managing contractor should estimate the costs required to complete the facility. Estimating and potentially accruing these residuals costs, rather than waiting until all costs have been realized, is necessary to expedite the deobligation of funds. Costs normally estimated include the following:

- Open purchase orders awaiting residual equipment, initial spares, or final vendor/contractor invoicing
- Construction services necessary to complete any remaining punch list items
- Outstanding claims
- Administrative and management labor to support and process closeout activities

Example Final Cost Report, Page 1

Sheet No. 1 of 3

UNITED STATES
DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE

FINAL COST REPORT

For: ____________________
SANDIA NATIONAL LABORATORIES

Budget Project No. 39DP01000GPD101000000

Directives No. ____________

Construction Contractor ____________________

Architect – Engineer ____________________

Date Prepared: ____________

ALLOCABLE COSTS	
Allocable Element	Dollar Value
ED&I:	
Design	
Building	
Occupancy	
Improv'mts to Land	
Utilities	
Const Mgmt/Insp	
PROJECT MGMT:	
Project Mgmt	
Documentation	
TOTAL	$0.00

SYMMARY OF PROJECT CHARGES	
ASSET TYPE COSTS	
GOVERNMENT FURNISHED MATERIAL	
OTHER COSTS	
ALLOCABLE COSTS	
TOTAL	$0.00

WORK BREAKDOWN STRUCTURE (WBS) SUMMARY	
WBS Element	Dollar Value
AUTHORIZED FUNDS	
WBS COSTS:	
ED&I	
Construction	
Equipment	
Management	
Contingency	
TOTAL COSTS	0.00
BALANCE	$0.00

Figure 19-6. Example Final Cost Report, Page 1

Example Final Cost Report, Page 2

Sheet No. 2 of 3

UNITED STATES
DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE

FINAL COST REPORT

For: SANDIA NATIONAL LABORATORIES

Budget Project No. 39DP01000GPD101000000

1 Asset Type Number	2 Description of Asset Types	3 Quantity	4 Unit	5 Asset Type Costs	6 GFM	7 Other Costs	8 Allocable Costs	9 Total
	INTERIOR							
	Building & Structures							
501	Owned Buildings							$0.00
550	Other Structures							$0.00
	Equipment							
710	Heavy Mobile Equipment							$0.00
715	Hospital & Medical Equip							$0.00
720	Laboratory Equipment							$0.00
725	Motor Vehicles & Aircraft							$0.00
730	Office Furniture and Equip							$0.00
735	Process Equip Personal Prop							$0.00
740	Railroad Rolling Stock							$0.00
745	Reactor/Accelerators (Personal)							$0.00
750	Security & Protection Equip							$0.00
755	Shop Equipment							$0.00
770	ADP Equipment							$0.00
775	ADP Software							$0.00
780	Portable Communication Electronic Equip							$0.00
799	Miscellaneous Equip							$0.00
803	Improvement to Property of Others – Equipment							$0.00

Figure 19-6. Example Final Cost Report, Page 2

Example Final Cost Report, Page 3

Sheet No. 3 of 3

UNITED STATES
DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE

FINAL COST REPORT

For: SANDIA NATIONAL LABORATORIES

Budget Project No. 39DP01000GPD101000000

1	2	3	4	5	6	7	8	9
Asset Type Number	Description of Asset Types	Quantity	Unit	Asset Type Costs	GFM	Other Costs	Allocable Costs	Total
	EXTERIOR							
	Utility Systems							
610	Communications Sytems							$0.00
615	Electric Generating Trans & Dist Systems							$0.00
620	Fire Alarm Systems							$0.00
625	Gas Production, Trans & Dist. Systems							$0.00
630	Irrigation Systems							$0.00
635	Railroad Systems							$0.00
640	Sewage Systems							$0.00
645	Steam Generation & Dis Systems							$0.00
650	Water Supply, Pump & Dist System							$0.00
670	Process Equipment							$0.00
	Improvements to Land:							
401	Land							$0.00
410	Land Rights							$0.00
430	Minerals							$0.00
460	Site Prep., Grading & Landscaping							$0.00
470	Roads, Walks, and Paved Areas							$0.00
480	Fences and Guard Towers							$0.00
490	Other Improvements to Land							$0.00
	Other Asset Types							
800	Improvements to Property of Others							$0.00
900	Unclassified Plant & Equipment							$0.00
999	Other							$0.00
+	Total			$0.00	$0.00	$0.00	$0.00	$0.00

Figure 19-6. Example Final Cost Report, Page 3

Typically, the Final Cost Report contains the following information:

- Project number, title, and budget and reporting classification.
- Amount of original deobligation and subsequent obligations or deobligations.
- Cost summary organized in the same categories as the original project data sheet.
- Capital investment from the project and the value of Plant and Capital Equipment adjustments.

Once the Final Cost Report has been prepared, estimated residual costs can be accrued in the site accounting system. Accruing the estimated residual project costs will facilitate an uncosted obligations balance of zero for the Prior Year Construction Projects Report (mandated by the House of Representatives in the Energy and Water Development Appropriations Bill of 1995.) Reserve accounts can be established within the site accounting system to collect estimated project costs, and residual balances (differences between accruals and actuals) can be liquidated in accordance with established site accounting practices.

In parallel with Final Cost Report activities, the project can be removed from the Department's Construction Work in Progress (CWIP) account and placed in the appropriate capital assets account. Removing a project or portions of a project from the CWIP account once beneficial occupancy has occurred complies with DOE O 534.1, ACCOUNTING. Removing the project from the CWIP account also facilitates financial closeout to support input to the annual Prior Year Construction Projects Report. The project can be considered financially closed once it has been removed from the CWIP account and the project's unobligated balance equals zero.

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Practice 20

20 Appendix

APPENDIX

APPENDIX A

REQUIREMENTS

SECTION #	"SHALL" STATEMENTS	PAGE #
Section 1	An acquisition strategy serving the Government's best interests shall be developed and documented in the Acquisition Plan.	1-4
	The plan shall specify the dates (milestones) when decisions should be made to facilitate attainment of the acquisition objectives. The plan shall address all the technical, business, management, and other significant considerations that will control the acquisition process.	1-4
	An Integrated Project Team (IPT) shall be responsible for developing the Acquisition Plan.	1-5
	At specified times or whenever significant changes occur, the IPT shall review and revise the plan, as appropriate.	1-5
	If an MOU is used it shall be consistent with the PEP.	1-9
Section 2	In all cases, the Justification of Mission Need shall include • a description of the conditions or regulatory requirements requiring action. • benefits to the Department of Energy (DOE) and the public. • alternative actions considered. • an outline scope definition. • planning/feasibility cost estimate. • preliminary acquisition plan. • planning/feasibility schedule(s) and milestones.	2-2
	The IPT shall also include the contractor project manager.	2-2
	Project documentation shall support the request for CD-1, which establishes the project's preliminary schedule and cost baseline ranges.	2-3
	With the completion of the Project Planning phases, those documents required to obtain Critical Decision-1 (CD-1, Approval Preliminary Baseline Range) approval shall also be completed, approved and provided. These include • an Acquisition Plan. • a Conceptual Design Report. • a Preliminary Hazard Analysis Report. • a Preliminary Project Execution Plan. • a design funding estimate. • preliminary baseline ranges for scope, schedule, and cost. • a Project Data Sheet for design. • a Verification of Mission need.	2-3

SECTION #	"SHALL" STATEMENTS	PAGE #
Section 2	The preliminary project scope shall be defined in a Work Breakdown Structure (WBS) and WBS dictionary that are developed based on the project's major elements and deliverables.	2-3
	Project cost and schedule ranges shall be developed based on the project WBS.	2-4
	As required by DOE O 413.X, in conjunction with the CD-1 submittal, these documents shall be submitted for SAE/AE approval.	2-4
	The project manager shall not commit to the performance of any tasks without confirming the availability of funds.	2-4
	Remediation of operable or waste units shall be accomplished through establishing and executing projects.	2-6
	EM work that may be categorized as conventional shall be projectized and managed as a separate project.	2-7
	A facility shall be characterized for types and amounts of contamination, alternative corrective actions developed, and the preferred alternative selected.	2-11
Section 3	The ISM Guiding Principles and Core Functions provided in DOE P 450.4, Safety Management System Policy, shall be applied to ensure that safety is integrated into design.	3-5
	The ISM Guiding Principles and Core Functions provided in DOE P 450.4, Safety Management Systems Policy, shall be applied to ensure that safety is integrated into design.	3-5
	Protecting the public, the workers, and the environment shall be a priority for all new design, construction, modification, or remediation.	3-6
	Each DOE project shall be implemented under a written environmental management process to anticipate and meet growing environmental performance expectations, and to ensure ongoing compliance with national and international regulatory requirements.	3-12
	The environmental baseline for the project shall be established prior to any work being performed at the site.	3-13
	Therefore the IPT shall include support from an environmental specialist.	3-14
	This plan outlines the steps that shall be followed in responding to situations in which hazardous substances, pollutants/contaminants, or oil are inadvertently released into the environment.	3-15
	The Order and Rule provide the basic areas to be covered by the project Quality Assurance Program. For nuclear projects, 10 CFR 830.120 and its attendant Price Anderson Act Program shall be implemented. For other programs, DOE Order 414.1A shall be applied.	3-16
	The Integrated Project Team shall prepare a QAP at the earliest possible stage; no later than the beginning of conceptual design.	3-18
	As early as possible (but no later than the beginning of conceptual design), the quality standard to be applied shall have been selected and the Quality Assurance Plan (QAP) prepared.	3-20
Section 4	Contracting and other procurements shall consider the available funds to avoid liability.	4-5
Section 5	If LPSOs have project delivery responsibility, they shall establish project management support offices that report directly to them, to provide project management support, throughout their organization.	5-3
	The team leader shall be the Federal project manager.	5-7
	However, IPT support shall be each member's first priority.	5-7

SECTION #	"SHALL" STATEMENTS	PAGE #
Section 6	Program funds needed to develop the proposed project's conceptual design shall be approved and a limited review accomplished that validates the mission need and funding request..	6-1
	EM work that may be categorized as conventional shall be projectized and managed as a separate project	6-3
Section 7	The project manager shall be held responsible and accountable for ensuring the successful completion of the project.	7-4
	Project roles and responsibilities of the DOE and contractor members of the IPT shall be defined and documented in the PEP and/or formal memoranda of understanding if not covered in the PEP.	7-5
	Development of a formal, detailed Project Execution Plan (PEP) by the IPT shall be performed for all projects.	7-6
	The project manager shall control changes to ensure changes are identified, coordinated and communicated, and that each approved change benefits the project.	7-11
	All change requests shall be documented, evaluated for project impact, approved and reconciled with the approved project baseline before physically implementing a change.	7-11
	Change control systems shall include Change Control Boards (CCB) that are responsible for reviewing and approving or rejecting change requests. The authority and responsibility of a CCB shall be defined in the CCB charter and agreed upon by key stakeholders.	7-11
	The project manager, with the support of the IPT, shall establish a turnover, occupancy, stakeholder acceptance, and user-acceptance process that includes punch-list item resolution, user walkthroughs, and verification of requirement compliance and system startup for proper operation.	7-11
	OECM shall provide the IPR report for preview prior to the critical decision meeting.	7-14
	Under the direction of the project manager, the project shall organize, schedule, and present project reviews based on user needs (tailored approach).	7-14
	Reviews are an important project activity and shall be planned as an integral part of the project, based on project complexity, duration and Critical Decision points.	7-15
Section 8	A project manager shall review CD-0 documentation and ensure top-level deliverables and/or functions have been defined.	8-1
	Regardless of the source, each requirement shall have a documented basis.	8-2
Section 9	The project manager shall verify selected solutions meet validated requirements for high-risk structures, systems, and components.	9-4
	After construction, the project manager shall test and inspect systems in accordance with the validated requirements and developed functional acceptance criteria	9-4
Section 11	The project manager shall develop a Risk Management Plan.	11-1
Section 12	The project shall clearly define and document the end product(s) to be provided to a user.	12-2
	The development of integrated project technical, schedule and cost baselines shall be aligned with DOE strategies, priorities, and goals.	12-7
	Any change to an approved baseline shall be thoroughly reviewed, understood, documented, and formally approved through a structured change control process.	12-8
	The schedule baseline shall be resource-loaded at the appropriate level to facilitate costing and budgeting.	12-8

SECTION #	"SHALL" STATEMENTS	PAGE #
Section 12	Schedule activities shall be activity-based when possible, with a strong relationship between schedule and cost estimate activities.	12-9
	The cost estimates shall be prepared using appropriate estimating methodologies.	12-9
	The cost baseline shall reflect all capital, expense, R&D, and outside funds required from preconceptual design to beneficial or user occupancy. The cost baseline shall also include escalation calculations using the DOE approved escalation rates.	12-9
	The application of contingency shall be considered in all scope, schedule, and cost baselines as being both prudent and necessary. Contingency shall not be used to avoid the effort required to prepare a properly detailed and documented cost estimate	12-10 12-10
	Contingency shall be controlled, approved, tracked and documented, based upon established and approved levels of control	12-10
	A schedule contingency shall be developed for each project task, with the amount of contingency assigned to the various activities reflecting the importance, cost, and difficulty of the task.	12-10
	In addition, a contingency usage log shall be maintained to document contingency usage by date, purpose, and amount.	12-11
	Therefore, TPC baseline shall be established with a high degree of confidence so that project completion can be achieved within the cost and schedule baselines.	12-11
	The TPC for the performance baseline shall be established at CD-2.	12-11
	In establishing the performance baseline, project completion shall be clearly and unambiguously defined.	12-11
	From a Congressional accountability perspective, the Performance Baseline shall capture all project costs (Total Project Cost (TPC) includes both the capital and OPEX components) even if the project is fully OPEX funded.	12-11
Section 14	Project changes shall be identified, controlled, and managed through a traceable, documented and dedicated change-control process.	14-1
	Baseline change control should be established early in a project's life cycle, but shall be organized and functioning prior to requesting CD-2.	14-1
	Each organizational level (as appropriate and documented in the PEP) shall establish a CCB for disposition of baseline change proposals within their level of authority/control.	14-2
	The proposed baselines and thresholds for each project shall be documented in the Project Execution Plan, and approved at the Approve Performance Baseline, the CD-2, or the equivalent decision point.	14-3
	The initiator of a change proposal shall prepare the change request describing the change and identifying the amount of budget required or to be returned.	14-3
Section 15	Each DOE project shall develop and implement a comprehensive, yet tailored, performance measurement/earned value system.	15-1
	In addition, as appropriate, the application of performance measurement/earned value shall be imposed on project suppliers, vendors, manufacturers, and support organizations.	15-2
	For all projects, the appropriate AE shall conduct a quarterly project performance review with the Federal Project Manager and staff.	15-3
	However, these contracts and contractors shall also have adequate control systems that suit the nature of the effort and reflect good business practices.	15-5

SECTION #	"SHALL" STATEMENTS	PAGE #
Section 15	Systematic measurement of baseline performance shall be conducted for each project in order to facilitate timely, meaningful, and proactive monitoring.	15-5
	As a project progresses from initiation through execution, performance measurement criteria shall be periodically reviewed and updated.	15-6
	Regardless of the EVMS implemented on a project, each project shall (on a tailored basis) prepare a list of metrics that can be used to gauge project progress on a gross or overall basis.	15-7
Section 16	Early in the project life-cycle, the project manager shall prepare a responsibility/authority matrix that identifies a responsible individual for each project work task.	16-2
	Each Federal project manager shall prepare formal Memoranda of Understanding with management, user and contractor project manager(s) as early as possible, but prior to requesting CD-2.	16-3
	Each memoranda shall be timed, dated and signed by each involved individual.	16-3
	A project manager shall prepare and issue a project charter which defines the project and the job descriptions for all team members.	16-3
Section 17	Additional reporting requirements, if any, shall be determined by the DOE Federal project manager and the responsible DOE program office. Agreements will be documented in the Project Execution Plan.	17-7
	The project manager shall submit quarterly project status reports using the data elements, analyses and narrative information specified above.	17-8
	DOE program managers shall provide project status reports to the Acquisition Executive on a quarterly basis, including their assessment of project performance as required by the Acquisition Executive.	17-8
	When projects are performed under contract or when they involve significant procurement activity, particular attention must be given to archiving financial records.	17-8
	The project manager shall prepare or have prepared component and system test procedures, perform or witness the tests, document the test results, and complete or have completed all required corrective actions.	18-2
	Turnover of a completed project shall include the turnover of appropriate project documentation/records to the user.	18-3
	At completion, the project shall prepare and distribute a lessons learned document.	18-3
Section 18	A project manager shall perform or assure these activities are performed prior to turnover, project closeout, and personnel reassignment.	18-3
	The project shall consider, plan, and work towards ORR/RA activities throughout the project lifetime. In addition, the project shall initiate all actions and activities that will improve or accelerate the ORR/RA process.	18-4
Section 19	To ensure orderly closeout of a project, the project shall, at the direction of DOE, and once all costs are incurred against the project with invoices and contracts closed, prepare a project closeout report following the approval of Critical Decision 4, Approve Start of Operations or Project Closeout.	19-2

APPENDIX B

REFERENCES

The Directive system is the means by which DOE policies, requirements, and responsibilities are developed and communicated throughout the DOE complex.

Department of Energy Directives include policies, orders, notices, manuals, and guides, that are intended to direct, guide, inform, and instruct employees in the performance of their jobs, and enable them to work effectively within the Department and with agencies, contractors, and the public.

The current list of directives is updated monthly and is available on the Internet in both .pdf and .wpd formats. The list can be accessed from the Explorer website at URL: http://www.explorer.doe.gov.1776/htmls/regs/doe/previous/html.

DOE Current Directives—new series, old series, headquarters, secretarial notices.

DOE Draft Directives—all DOE draft directives for review and comment.

DOE Archived Directives—DOE archived directives.

Supplemental Directives—Field directives.

DOE Directives Reference Tools—current checklist of DOE directives, DOE glossary, baseline directives by contract, crosswalk, and directives identified for sunset review.

Other Useful Information—Federal Register, DOE (see page 12-9 of the manual), CFRs, DOE forms, secretarial delegation of authority, etc.

DEPARTMENT OF ENERGY

Atomic Energy Act of 1954, Pub. L. 54-703; 42 USC § 2011 et. seq. (August 30, 1954)

DOE/EH-0173T, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance

DOE/EH-0573. Environmental Management Systems Primer for Federal Facilities

DOE G 120.1-5, Guidelines for Performance Measurement, July 1996

DOE O 130.1, Budget Formulation Process

DOE O 151.1, Comprehensive Emergency Management System,

DOE O 231.1, Environmental, Safety, and Health Reporting

DOE O 231.1 Change 1, Environmental, Safety, and Health Reporting, 10-26-95

DOE O 414.1A, Quality Assurance (and implementing Guide)

DOE P 411.1, Safety Management Functions, Responsibilities, and Authorization Policy

DOE M 411.1-1A, DOE Safety Management Functions, Responsibilities, and Authorities Manual

DOE P 413.1, Program and Project Management Policy for the Planning, Programming, Budgeting, and Acquisition of Capital Assets, 6-10-00

DOE O 413.X, (Draft) Program and Project Management for the Acquisition of Capital Assets

DOE G 414.1-2, Quality Assurance Management System for use with 10CFR 830.120 and DOE O 414.1

DOE O 414.1A, Quality Assurance (and implementing Guide)

DOE O 420.1, Change 2, Facility Safety (and implementing Guide)

DOE G 420.1-1, Section 2, Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for Use with DOE O 420.1, Facility Safety

DOE O 420.2, Change 1, Safety of Accelerator Facilities

DOE O 425.1A, Startup and Restart of Nuclear Facilities

DOE O 430.1, Life Cycle Asset Management

DOE G 430.1-1, Cost Estimating Guide

DOE G 430.1-2, Implementation Guide for Surveillance and Maintenance during Facility Transition and Disposition

DOE G 430.1-3, Deactivitation Implementation Guide

DOE G 430.1-4, Decommissioning Implementation Guide

DOE O 430.1A, Life Cycle Asset Management, 10-14-98

DOE O 435.1, Radioactive Waste Management (and implementing Manual and Guides)

DOE O 440.1A, Worker Protection Management for Federal and Contractor Employees (and implementing Guides)

DOE P 441.1, DOE Radiological Health and Safety Policy (and implementing Guides)

DOE P 450.1, Environmental Safety and Health Policy for Department of Energy Complex

DOE P 450.2A, Identifying, Implementing and Complying with ES&H Requirements

DOE P 450.3, Authorizing Use of the Necessary and Sufficient Process for Standards-Based ES&H (and implementing Manual and Guides)

DOE P 450.4, Safety Management System Policy (and implementing Guide)

DOE G 450.4-1A, Integrated Safety Management System Guide for use with DOE P 450.4, Safety Management System and DEAR Safety Management System Control clauses

DOE P 450.5, Line Environment, Safety and Health Oversight

DOE P 450.6, Secretarial Policy Statement Environmental Safety and Health

DOE O 451.1A, National Environmental Policy Act Compliance Program

DOE O 460.1A, Packaging and Transportation Safety

DOE O 460.2, Departmental Materials Transportation and Packaging Management

DOE P 1210.1, Public Participation

DOE O 534.1, Accounting

DOE O 5400.1, Change 1, General Environmental Protection Program

DOE O 5400.5, Change 2, Radiation Protection of the Public and the Environment

DOE O 5480.23, Nuclear Safety Analysis Report

DOE O 5480.30, Nuclear Reactor Safety Design Criteria

DOE O 5480.4, Environmental Protection, Safety and Health Protection Standards

DOE O 5700.2D, Cost Estimating, Analysis, and Standardization

DOE O 6430.1A, General Design Criteria

DOE-EM-STD-5502-94, Hazard Baseline Documentation

DOE-EM-STD-5503-94, DOE Limited Standard EM Health and Safety Plan Guidelines

DOE-HDBK-3012-96, Guide to Good Practices for Operational Readiness Reviews, Team Leaders Guide

DOE-HDBK-3027-99, Integrated Safety Management System (ISMS) Verification Team Leader's Handbook

DOE-STD-1120-98, Integration of Environment, Safety and Health into Facility Disposition

DOE-STD-1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE O 5480.23, Nuclear Safety Analysis Reports

DOE-STD-3009-94, Ch. Notice 1, Preparation Guide for US DOE Nonreactor Nuclear Facility Safety Analysis Report

DOE-STD-3009-94, Preparation Guide for US DOE Nonreactor Nuclear Facility Safety Analysis Reports

DOE-STD-3024-98, Content of System Design Descriptions

DOE-STD-7501-99, DOE Corporate Lessons Learned Program

DEAR 970-5204-2, Integration of Environmental, Safety and Health into Work Planning and Execution

DEAR Guide: A DOE Guide to the Award and Administration of Contracts, Office of Policy, Office of Procurement and Assistance Management, 9-30-98

EM/CAT, U.S. Department of Energy Cost Estimating Handbook for Environmental Restoration, October 1990

Human Factors Design Guidelines for Maintainability of Department of Energy Nuclear Facilities, UCRL-15673, 1985

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APPENDIX C

ACRONYMS

ASME .... American Society of Mechanical Engineers

ACWP .... Actual Cost of Work Performed

ALARA .... As Low As Reasonably Achievable

AE .... Acquisition Executive

ANSI .... American National Standards Institute

BAC .... Budget at Completion

BCWP .... Budgeted Cost of Work Performed

CADD .... Computer Aided Drafting and Design

BCWS .... Budgeted Cost of Work Scheduled

BR .... Budget Request

CAA .... Clean Air Act

BY .... Budget Year

CAM .... Cost Account Manager

CBB .... Contract Budget Baseline

CDR .... Conceptual Design Report

CCB .... Change Control Board

CD .... Critical Decision

CDR .... Conceptual Design Report

CERCLA .... Comprehensive Environmental Response, Compensation, and Liability Act

CFO .... Chief Financial Officer

CFR .... Code of Federal Regulations

COO .... Chief Operating Officer

CO .... Contracting Officer

COTR .... Contracting Officer's Technical Representative

CPDS .... Construction Project Data Sheet

CRD .... Contractor Requirements Document

CPI .... Cost Performance Index

CV .... Cost Variance

CWA .... Clean Water Act

CX .... Categorical Exclusion

D&D .... Decontamination and Decommissioning

DEAR .... Department of Energy Acquisition Regulation

DoD .... U.S. Department of Defense

DOE .... U.S. Department of Energy

DOE-MR .... U.S. Department of Energy Management Reserve

DNFSB .... Defense Nuclear Facilities Safety Board

EA .... Environmental Assessment

EAC .... Estimate at Completion

EE/CA .... Environmental Evaluation/Compliance Assessment

EIR .... External Independent Review

EIS .... Environmental Impact Statement

EM .... Environmental Management

EPA .... U.S. Environmental Protection Agency

ER .... Environmental Restoration

ESAAB .... Energy Systems Acquisition Advisory Board

ES&H .... Environmental Safety and Health

ETC .... Estimate to Complete

EVMS .... Earned Value Management System

F&Rs............... Functions and Requirements

FAR .... Federal Acquisition Regulations

FFCA .... Federal Facilities Compliance Act

FM .... DOE Office of Field Management

FPM................. Federal (DOE) Project Management

EVMS .... Earned Value Management System

FONSI .... Finding of No Significant Impact

FSAR .... Final Safety Analysis Report

GAO .... Geeral Accounting Office

GPG................. Good Practice Guide

GPP .... General Plant Project

GPRA .... Government Performance and Results Act

HAD .... Hazard Assessment Documentation

HAR .... Hazards Analysis Report

HR..................... Human Resources

HQ .... Headquarters

IFC.................... Issued for Construction

IFD.................... Issued for Design

ICE .... Independent Cost Estimate

ICO................... Interface Control Document

IIR..................... Internal Independent Review

IMS................... Integrated Master Schedule

IPABS .... Internal Planning, Accountability, and Budget System

IPL .... Integrated Project Listing

IPR .... Independent Project Review

IPS .... Integrated Project Schedule

IPT .... Integrated Project Team

ISM .... Integration Safety Management

ISMS .... Integrated Safety Management System

ISO .... International Standards Organization

IT .... Information Technology

JMN .... Justification of Mission Need

LCAM .... Life Cycle Asset Management

LLP .... Long-Lead Procurement

LPSO .... Lead Program Secretarial Office

M&I .... Management and Integration

M&O .... Management and Operating

MEM .... Management Evaluation Matrix

MS .... Major System project

NARA .... National Archives and Records Administration

NCP .... National Contingency Plan

NEPA .... National Environmental Policy Act

NNSA .... National Nuclear Security Administration

NPDES .... National Pollution Discharge Elimination System

NQA-1 .... American Society of Mechanical Engineers/National Quality Assurance Standard - 1

NRC .... National Research Council

OBS .... Organizational Breakdown Structure

OECM .... Office of Engineering and Construction Management

OMB .... Office of Management and Budget

OPC .... Other Project Costs

OPEX .... Operating/Expense

ORR .... Operational Readiness Review

OSHA .... Occupational Safety and Health Administration

P&ID .... Process and Instrumentation Diagram

PBC .... Performance-Based Contract

PBS .... Project Baseline Summary

PCR .... Project Closeout Report

PDRI .... Project Rating Definition Index

PDS .... Project Data Sheet

PED .... Project Engineering and Design

PEP .... Project Execution Plan

PERT .... Program Evaluation and Review Technique

PI .... Performance Indicator

PM .... Project Management

PMB .... Performance Measurement Baseline

PMBOK .... Project Management Book of Knowledge

PMCDP .... Program/Project Management Career Development Program

PMP .... Project Management Plan

PSAR .... Preliminary Safety Analysis Report

PSO .... Program Secretarial Officer

QA .... Quality Assurance

QAP .... Quality Assurance Plan

QAPP .... Quality Assurance Program Plan

QSL .... Qualified Seller List

RA .... Readiness Assessment

R&D .... Research and Development

RAM .... Responsibility Assignment Matrix

RCRA .... Resource Conservation and Recovery Act

RFP .... Request for Proposal

RFQ .... Request for Quotations

RI/FS .... Remedial Investigation/Feasibility Study

ROD .... Record of Decision

RSE .... Remedial Site Evaluation

ROM .... Rough Order of Magnitude

SAE .... Secretarial Acquisition Executive

SAR .... Safety Analysis Report

SB .... Small Business

SB/PP .... Statement of Basis/Proposed Plan

SDB .... Small Disadvantaged Business

SE .... Systems Engineering

SEB .... Source Evaluation Board

SES .... Senior Executive Service

SOW .... Scope of Work

SPI .... Schedule Performance Index

SV .... Schedule Variance

T&PRA .... Technical and Programmatic Risk Analysis

TEC .... Total Estimated Cost (Capital)

TPC .... Total Project Cost

TPCE .... Total Project Cost Estimate

TSCA .... Toxic Substances Control Act

TTR .... Technical Task Report

VAR .... Variance Analysis Report

VE .... Value Engineering

WBS .... Work Breakdown Structure

Practice 21

21

Glossary

GLOSSARY

DEFINITIONS OF TERMS

The following is a list of definitions of terms that are unique or nearly unique to project management. Also included are terms that are not unique to project management, but are used differently or with a narrower meaning than in general everyday usage. Many of the terms have broader, or sometimes different, dictionary definitions.

Acceptance. The official act of signing a reimbursable agreement, e.g., bilateral sales contract or interagency agreement, by a Department of Energy (DOE) contracting officer or DOE official to whom such authority has been delegated. Acceptance commits DOE and/or its contractor to perform Work for Others. Authority to sign and execute bilateral sales contracts can be delegated to the DOE contractor by the Head of a Field Element.

Acceptance Testing. The performance of all testing necessary to demonstrate that installed equipment will operate satisfactorily and safely in accordance with plans and specifications. It includes hydrostatic, pneumatic, electrical, ventilation, mechanical functioning, and run-in tests of portions of systems, and finally of completed systems.

Accrued Cost. See APPLIED COST.

Accountability. The requirement, obligation, or willingness of an individual to accept responsibility for the outcome, results and consequences of their actions and decisions. In a project setting, accountability is inseparable from authority and responsibility.

Accountability Matrix. See RESPONSIBILITY ASSIGNMENT MATRIX.

Acquisition Executive. The individual designated by the Secretary of Energy to integrate and unify the project management system and monitor implementation of prescribed policies and practices. Approves the initiation of a major system project (or a selected other project) and its transition through phases of the acquisition process and other subphases involving major commitments; selects from among competing systems those that are to be advanced to development, demonstration, and production/operation; and authorizes development of a noncompetitive (single concept) system.

Acquisition Plan. Provides the procurement and contracting detail for elements of a system, program or project. The Acquisition Plan is execution oriented and provides the framework for conducting and accomplishing the procurements and includes actions from solicitation preparation through contract award administration.

Acquisition Proponent. The DOE component having the primary responsibility for research, development, demonstration, production or operation of a major system project (to include, when applicable, the system for its logistic support) that meets Departmental objectives in carrying out DOE missions.

Acquisition Strategy. Describes how the Department will acquire capital assets and establishes the framework within which detailed acquisition planning and program execution are accomplished. Once approved, it should reflect the approving authority's decisions on all major aspects of the contemplated acquisition.

Action Plan. A description of reportable problems or reportable financial management system nonconformances, their root cause(s), and the action(s) planned for correcting them.

Activity. An element of work performed during the course of a project. An activity normally has an expected duration, an expected cost, and expected resource requirements. Activities are often subdivided into tasks.

Actual Cost of Work Performed (ACWP). Total costs incurred (direct and indirect) in accomplishing an identified element or scope of work during a given time period. See also EARNED VALUE.

Administrative Closure. Generating, gathering, and disseminating information to formalize project completion.

Authority. The power or right granted or assigned to an individual to (a) lead, guide, and direct an activity, (b) make decisions, (c) authorize action, and (d) influence or control other individuals. In a project setting, authority is inseparable from accountability and responsibility.

Backfit. The imposition of a new or proposed nuclear safety requirement that dictates the modification of, or addition to: (1) systems, structures, and components of a facility; (2) the existing or approved design of a facility; or (3) the procedures or organization required to design, construct, or operate a facility.

Bar Chart. A graphic display of schedule-related information. In the typical bar chart, activities or other project elements are listed down the left side of the chart, dates are shown across the top, and activity durations are shown as date-placed horizontal bars. Also called a GANTT CHART.

Baseline. A quantitative expression of projected scope, schedule, and cost requirements. Baseline establishment includes criteria to serve as a base or standard for measurement during the performance of an effort and the established plan against which the status of resources and the progress of a project can be measured.

Baseline and Change Control Levels. The project baseline consists of scope, schedule, and TPC as stated on the project data sheet, the project baseline summary, or similar documents. A baseline range is established at CD-1, Approve Preliminary Baseline Range, for tracking purposes. A performance baseline, against which project performance will be measured, is established at CD-2, Approve Performance Baseline.

Baseline Change Control Board. A multi-discipline functional body of representatives designated and chartered by the appropriate management level to ensure the proper definition, coordination, evaluation, and disposition of all proposed changes to approved baselines of projects that are within their chartered jurisdiction.

Baseline Change Proposal. The instrument/document prepared to provide a complete description of a proposed change and its resulting impacts on project baselines.

Benchmarking. An improvement process in which an organization, agency or company measures its performance against that of best-in-class organizations, agencies, or companies; determines how those organizations, agencies, or companies achieved their performance levels; and uses the information to improve its own performance. Benchmarking can compare strategies, operations, processes, and procedures.

Beneficial Use or Occupancy Date. The process by which a facility, portions thereof, or the last piece of principal equipment, is released for use by others, prior to final acceptance. Nonintegral or subsidiary items and correction of design inadequacies subsequently brought to light may be completed after this date. On multiple-facility projects, beneficial use of the overall project will be the beneficial use date of the last major building or facility. This activity is always documented and approved by the responsible parties.

Budget at Completion (BAC). The estimated total cost of the project when finished

Budgeted Cost of Work Performed (BCWP). The sum of the approved cost estimates (including any overhead allocation) for activities (or portions of activities) completed during a given period (usually project-to-date). See also EARNED VALUE.

Budgeted Cost of Work Scheduled (BCWS). The sum of the approved cost estimates (including any overhead allocation) for activities (or portions of activities) scheduled to be performed during a given period (usually project-to-date). See also EARNED VALUE.

Capital Assets. Land, structures, equipment, and information technology (e.g., hardware, software, and applications) that are used by the Federal Government and have an estimated useful life of 2 years or more. Capital assets include environmental restoration (decontamination and decommissioning) of land to make useful leasehold improvements and land rights, and assets whose ownership is shared by the Federal Government with other entities. This does not apply to capital assets acquired by State and local governments or other entities through DOE grants. Capital Assets do not include intangible assets, such as the knowledge resulting from research and development and education and training.

Change Control Board (CCB). A formally constituted group of stakeholders responsible for approving or rejecting changes to project baselines.

Change in Scope. A change in objectives, work plan, or schedule that results in a material difference from the terms of an approval to proceed previously granted by higher authority. Under certain conditions, stated in the approval instrument, change in resources application may constitute a change in scope. Under contractual agreement, contracting officers are the only Government personnel authorized to issue a change order of contract modification to a contractor/performer, in order to implement a change of scope. A change in scope may also affect the availability of current year funds until the proper congressional notification procedures have been executed.

Chart of Accounts. Any numbering system used to monitor project costs by category (e.g., labor, supplies, materials). The project chart of accounts is usually based upon the corporate chart of accounts of the primary performing organization.

Chief Operating Officer Watch List. All Federal project managers and their appropriate PSOs are required to inform the Deputy Secretary on MS project issues that may contribute to an expected unfavorable Level 0 scope change, an unexpected unfavorable Level 0 milestone schedule variance greater than 3 months, or an unexpected unfavorable cost variance in TEC or TPC. Projects that encounter significant cost and schedule variances and/or technical issues or projects that develop other problems may be placed on this list, projects require corrective action plans, specific corporate reporting requirements, and periodic review by the Deputy Secretary, arranged through OECM. These projects will be released from the list when Watch List milestones are completed, progress on corrective action warrants, or the project recovers (i.e., the variances fall back within established criteria).

Code of Accounts. Any numbering system used to uniquely identify each element of the work breakdown structure. See also CHART OF ACCOUNTS.

Commissioning. Commissioning is a systematic process for achieving, verifying, and documenting that the performance of the facility and its various systems meet the design intent and the functional and operational needs of the owners and occupants. The process extends through all phases of a project, from conceptualization to occupancy and operations, with numerous checks at each stage of the process to ensure that established procedures are followed.

Commitment. An administrative reservation of funds, prior to creation of an obligation. A commitment is based upon a valid request for procurement that authorizes the creation of an obligation without further recourse to the official responsible for assuring the availability of funds. (Note: This definition concerns commitments in the accounting sense and therefore differs from loan guarantee commitments.)

Communications Planning. Determining the information and communications needs of the project stakeholders.

Conceptual Design. Conceptual design encompasses those efforts to: (a) develop a project scope that will satisfy program needs; (b) assure project feasibility and attainable performance levels; (c) develop reliable cost estimates and realistic schedules in order to provide a complete description of the project for Congressional consideration; and (d) develop project criteria and design parameters for all engineering disciplines, identification of applicable codes and standards, quality assurance requirements, environmental studies, materials of construction, space allowances, energy conservation features, health safety, safeguards, and security requirements, and any other features or requirements necessary to describe the project.

Conditional or Provisional Acceptance. The acceptance of a unit or facility with a documented listing of the specific testing to be accomplished or work remaining including the furnishing of any outstanding submittals of technical and record data, to be completed by the construction contractor, and on or by what date the actions are scheduled to be complete.

Configuration. The functional and/or physical characteristics of hardware and/or software, as set forth in technical documentation and achieved in a product.

Configuration Acceptance. The systematic evaluation, coordination, approval (or disapproval), documentation, implementation, and audit of all approved changes in the configuration of a product after formal establishment of its configuration identification.

Construction. Any combination of engineering, procurement, erection, installation, assembly, demolition, or fabrication activities involved in creating a new facility, or to alter, add to, rehabilitate, dismantle, or remove an existing facility. It also includes the alteration and repair (including dredging, excavating, and painting) of buildings, structures, or other real property, as well as any construction, demolition, and excavation activities conducted as part of environmental restoration or remediation efforts. Construction does not involve the manufacture, production, finishing, construction, alteration, repair, processing, or assembling of items categorized as personal property.

Construction/As-built Services. Those activities required to assure that the project is constructed in accordance with the plans and specifications (e.g., construction inspection), and that the quality of materials and workmanship is consistent with the requirements of the project (e.g., materials testing). (See DEAR 936.605(c)(3) and (4), and DEAR 952.236.70 for additional details.)

Construction Completion Date. The date on which work normally performed by construction forces (including installation of equipment by operating contractors or others) is accepted by the Government. This includes the completion of all building items, the erection and/or installation of mechanical units and/or processing equipment, and the installation of all furnishings as required to make a full functioning building, facility, or process. Correction of minor deficiencies and exceptions may be accomplished after the recorded date.

Construction Management. Services that encompass a wide range of professional services relating to the management of a project during the pre-design, design, and/or construction phases. The types of services include development of project strategy, design review relating to cost and time consequences, value engineering, budgeting, cost estimating, scheduling, monitoring of cost and schedule trends, procurement, observation to assure that workmanship and materials comply with plans and specifications, contract administration, labor relations, construction methodology and coordination, and other management efforts related to the acquisition of construction.

Contingency. The amount budgeted to cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties. The amount of the contingency is a risk-based calculation that will depend on the status of design, procurement, and construction, and the complexity and uncertainty of the component parts of the project. Contingency is not to be used to avoid making an accurate assessment of expected cost.

Contingency Planning. The development of a management plan that identifies alternative strategies to be used to ensure project success if specified risk events occur.

Contract. A contract is a mutually binding agreement that obligates the seller to provide the specified product and obligates the buyer to pay for it. It includes all types of commitments that obligate the Government to an expenditure of funds and which, except as otherwise authorized, are in writing. In addition to a two-signature document, it includes all transactions resulting from acceptance of offers by awards or notices of awards; agreements and job orders or task orders issued thereunder; letter contracts; letters of intent; and orders, such as purchase orders under which the contract becomes effective by written acceptance or performance. It also includes contract modifications. Contracts generally fall into one of three broad categories: (a) Fixed price or lump sum contracts—this category of contract involves a fixed total price for a well-defined product. Fixed price contracts may also include incentives for meeting or exceeding selected project objectives such as schedule targets. (b) Cost reimbursable contracts—this category of contract involves payment (reimbursement) to the contractor for its actual costs. Costs are usually classified as direct costs (costs incurred directly by the project, such as wages for members of the project team) and indirect costs (costs allocated to the project by the performing organization as a cost of doing business, such as salaries for corporate executives). Indirect costs are usually calculated as a percentage of direct costs. Cost-reimbursable contracts often include incentives for meeting or exceeding selected project objectives such as schedule targets or total cost. (c) Unit price contracts—the contractor is paid a preset amount per unit of service (e.g., $70 per hour for professional services or $1.08 per cubic yard of earth removed) and the total value of the contract is a function of the quantities needed to complete the work.

Contract Administration. Managing the relationship with the seller.

Contract Advance Funding. Obligations to a contract or project, to cover future work or materials not yet ordered. The value of advanced funding is the difference between uncosted obligation and unfilled orders outstanding.

Contract Close-Out. Completion and settlement of the contract, including resolution of all outstanding items.

Contracting Officer. A person designated to enter into and/or review, modify, or terminate any contracts, financial assistance awards, and sales contracts, and make related determinations and findings.

Contracting Officer's Technical Representative. The individual in DOE who is assigned responsibility for overall technical monitoring of a contract and identified as such in the contract. The contracting officer's technical representative monitors the technical work performed under the contract, evaluates the contractor's performance, provides the contractor and the contracting officer with technical guidance, reports on contract status to DOE program and project management, and recommends corrective action when necessary.

Contractor. The term "contractor" is intended to mean and include all persons, organizations, departments, divisions, and companies having contracts, agreements, or a memorandum of understanding with DOE.

Control. The process of comparing actual performance with planned performance, analyzing variances, evaluating possible alternatives, and taking appropriate corrective action as needed.

Control (Cost) Account. The management control point at which actual costs are accumulated and performance determined. It represents the defined work assigned to one responsible organizational element for the lowest level work breakdown structure element and must contain the specific scope of work, definite schedule, assigned budget, unique identification, and method of measuring performance.

Control Charts. Control charts are a graphic display of the results, over time and against established control limits, of a process. They are used to determine if the process is "in control" or in need of adjustment.

Corrective Action. Changes made to bring expected future performance of the project into line with the plan.

Cost Budgeting. Allocating the cost estimates to individual project components.

Cost Control. Controlling changes to the project budget.

Cost Estimate. A documented statement of costs estimated to be incurred to complete the project. Cost estimates provide baselines against which cost comparisons are made during the life of a project.

Cost Estimating. Estimating the cost of the resources needed to complete project activities.

Cost Plus Fixed Fee (CPFF) Contract. A type of contract where the buyer reimburses the seller for the seller's allowable costs (allowable costs are defined by the contract) plus a fixed amount of profit (fee).

Cost Plus Incentive Fee (CPIF) Contract. A type of contract where the buyer reimburses the seller for the seller's allowable costs (allowable costs are defined by the contract), and the seller earns its profit if it meets defined performance criteria.

Cost Variance (CV). (1) Any difference between the estimated cost of an activity and the actual cost of that activity. (2) In earned value, BCWP less ACWP.

Costs to Date. Costs incurred to date by the contractor and reported to DOE, which are recorded as accrued costs. They represent all charges incurred for goods and services received and other assets required, regardless of whether payment for the charges has been made. This includes all completed work and work in process chargeable to the contract. Accrued costs include invoices for: (1) completed work to which the prime contractor has acquired title (2) materials delivered to which the prime contractor has acquired title (3) services rendered (4) costs billed under cost reimbursement, or time and material subcontracts for work to which the prime contractor has acquired title (5) progress payments to subcontractors that have been paid or approved for current payment in the ordinary course of business (as specified in the prime contract) and (6) fee profit allocable to the contract.

Critical Activity. Any activity on a critical path. Most commonly determined by using the critical path method. Although some activities are "critical" in the the dictionary sense without being on the critical path, this meaning is seldom used in the project context.

Critical Decision. A formal determination, made by DOE, at a specific point in a project that allows the project to proceed. Critical decisions occur in the course of a project, for example: prior to commencement of conceptual design, commencement of execution and prior to turnover.

Critical Path. In a project network diagram, the series of activities that determines the earliest completion of the project. The critical path will generally change from time to time as activities are completed ahead of or behind schedule. Although normally calculated for the entire project, the critical path can also be determined for a milestone or subproject. The critical path is usually defined as those activities with float less than or equal to a specified value, often zero.

Critical Path Method (CPM). A network analysis technique used to predict project duration by analyzing which sequence of activities (which path) has the least amount of scheduling flexibility (the least amount of float). Early dates are calculated by means of a forward pass using a specified start date. Late dates are calculated by means of a backward pass starting from a specified completion date (usually the forward pass's calculated project early finish date).

Customer. An organization, department, or individual that receives goods and/or services from another organization, department, or individual.

Deliverable. Any measurable, tangible, verifiable outcome, result, or item that must be produced to complete a project or part of a project. A report or product that satisfies one or more objectives and must be delivered to satisfy contractual requirements. Often used more narrowly in reference to an external deliverable, which is a deliverable that is subject to approval by the project sponsor or customer.

Demonstrate. To verify the soundness of the chosen design concept(s) in an environmentally acceptable manner, the technical and economic feasibility of new or advanced equipment, facilities, or processes by designing, constructing, testing, operating, and evaluating near-full-scale modules.

Demonstration. The verification of scale-up, economic, and environmental viability for commercial application, through design, construction, test, and evaluation of large-scale energy systems in operational circumstances.

Development. The development and test of systems and pilot plants judged to be technically and economically desirable as a means of achieving principal Departmental goals. Engineering development concerns itself with processes, preproduction components, equipment, subsystems, and systems. Initiation of work in this category is dependent upon successful demonstration of technical feasibility and economic potential during the technology phase.

Direct Cost. Any cost that can be specifically identified with a particular project or activity, including salaries, travel, equipment, and supplies directly benefiting the project or activity.

Directed Change. A change imposed on a project(s), with direction to implement, that affects one or more of the project's (projects') baselines. Example of directed changes include, but are not limited to: (a) Changes to approved budgets, or funding and (b) Changes resulting from DOE policy directives and regulatory or statutory requirements.

Duration (DU). The number of work periods (not including holidays or other nonworking periods) required to complete an activity or other project element. Usually expressed as workdays or workweeks. Sometimes incorrectly equated with elapsed time. See also EFFORT.

Earned Value (EV). (1) A method for measuring project performance. It compares the amount of work that was planned with what was actually accomplished to determine if cost and schedule performance is as planned. See also ACTUAL COST OF WORK PERFORMED, BUDGETED COST OF WORK SCHEDULED, BUDGETED COST OF WORK PERFORMED, COST VARIANCE, COST PERFORMANCE INDEX, SCHEDULE VARIANCE, AND SCHEDULE PERFORMANCE INDEX. (2) The budgeted cost of work performed for an activity or group of activities.

Engineering Change. An approved change to controlled identification documentation. An Engineering Change Proposal (ECP) is a recommended Engineering Change (EC). There are typically two classes of ECs: a. Class 1. Changes of configuration, which affects Departmental interest and requires approval from the appropriate approval authority or designated representative. Class 1 engineering changes are those which affect: (1) technical baseline requirements and/or (2) nontechnical contractual provisions such as fee, incentives, cost, schedule, guarantees, or deliveries. b. Class 2. Changes to a product that do not affect any of the Class 1 engineering change requirements. The Department's approval prior to implementation is not required, although such changes are subject to post-facto classification review by the project office. Other distinctions may be made at the discretion of the project manager.

Estimate. An assessment of the likely quantitative result. Usually applied to project costs and durations and should always include some indication of accuracy (e.g., ± x percent). Usually used with a modifier (e.g., preliminary, conceptual, feasibility). Some application areas have specific modifiers that imply particular accuracy ranges (e.g., order-of-magnitude estimate, budget estimate, and definitive estimate in engineering and construction projects).

Estimate At Completion (EAC). The expected total cost of an activity, a group of activities, or of the project when the defined scope of work has been completed. Most techniques for forecasting EAC include some adjustment of the original cost estimate based on project performance to date. Also shown as "estimated at completion." Often shown as EAC = Actuals-to-date + ETC. See also earned value and estimate to complete.

Estimate To Complete (ETC). The expected additional cost needed to complete an activity, a group of activities, or the project. Most techniques for forecasting ETC include some adjustment to the original estimate based on project performance to date. Also called "estimated to complete." See also earned value and estimate at completion.

Facilities. Buildings and other structures; their functional systems and equipment, including site development features such as landscaping, roads, walks, and parking areas; outside lighting and communications systems; central utility plants; utilities supply and distribution systems; and other physical plant features.

Field Office (FO). The designation for the nine major Departmental offices responsible for day-to-day management of designated functional activities.

Final Design. This continues the development of the project based on approved preliminary design. Definitive design includes any revisions required of the preliminary effort; preparation of final working drawings, specifications, bidding documents, cost estimates, and coordination with all parties that might affect the project; development of firm construction and procurement schedules; and assistance in analyzing proposals or bids. For a detailed description of the services provided during definitive design, see DEAR 936.605(c)(3) and (4), and DEAR 952.236.70.

Fast Tracking. Compressing the project schedule by overlapping activities that would normally be done in sequence, such as design and construction. Sometimes confused with concurrent engineering.

Final Acceptance. A written statement by the contracting officer or designee that the work performed by the construction contractor has been accepted as being in accordance with approved plans and specifications. The operating contractor should also be included in the final acceptance, if applicable, indicating acceptance of the facilities as constructed and the date the facilities are to be occupied or available for the use of the operating contractor.

Fixed Price Contracts. Fixed price contracts provide for a firm price or, under appropriate circumstances, may provide for an adjustable price for the supplies or services that are being procured. In providing for an adjustable price, the contract may fix a ceiling price, target price (including target cost), or minimum price. Unless otherwise provided in the contract, any such ceiling, target, or minimum price is subject to adjustment only if required by the operation of any contract clause that provides for equitable adjustment, escalation, or other revision of the contract price upon the occurrence of an event or a contingency.

Fixed Price Incentive Fee (FPIF) Contract. A type of contract where the buyer pays the seller a set amount (as defined by the contract), and the seller can earn an additional amount if it meets defined performance criteria.

Functional Manager. A manager responsible for activities in a specialized department or function (e.g., engineering, manufacturing, marketing).

Functional Organization. An organization structure in which staff are grouped hierarchically by specialty (e.g., production, marketing, engineering, and accounting at the top level; with engineering, further divided into mechanical, electrical, and others).

General Plant Projects (GPP). Congress has recognized DOE's need to provide for miscellaneous construction items that are required during the fiscal year and which cannot be specifically identified beforehand. Congress provides, annually, an amount for these purposes under the title of General Plant Projects.

Government Estimates. Estimates are used to determine the reasonableness of competitive bids received in connection with formally advertised construction contracts, and serve as a control in evaluating cost and pricing data in negotiated contracts. Normally, the Title II design estimate, after being reviewed and approved by the Government, is the basis for the Government estimate. However, the services of an operating contractor, architect-engineer, cost-plus-fixed-fee construction contractor (with respect to subcontracts), or construction manager may be used appropriately to prepare, review, or revise the Government estimate prior to Government approval (refer to FAR 36.203). Cost-type contractors shall be required to follow cost estimate procedures when subcontracting for construction services. Government review and approval of the Government estimate is not required when the estimate is within the limits established by the Government's approval of the cost-type contractors procurement system. The specifics of a Government estimate vary with the size and type of contract.

Incurred Costs. Costs are applied to the performance of the project. All costs incurred for a project are reported whether they arise from payments, cost accruals, or transfers of costs from other DOE locations or Federal agencies. Any time costs are incurred by cost-type contractors, the amount will be included in that period. Incurred costs also comprise payments made or due to date, including any retained percentages, and lump-sum and unit price contracts based on payment estimates approved by the contracting officer and designated representative for the purpose of making the progress or final payments on work performed to date. Costs shall not be accrued on the basis of a percentage of physical completion, unless the amounts of such costs are approved by the contracting officer or his or her designated representative as progress or partial payments.

Independent Assessment (Review). An assessment, made outside the normal advocacy chain, of a project's status or condition. In the project management system, it is made by the Office of Program/Project Management in its role of independent monitoring. It will consist of independent evaluation of all pertinent factors in order to provide a condition rating or detailed analysis of the project or system situation. Independent assessments will typically be provided in conjunction with Headquarters reporting to senior DOE management; advisory board decision reviews; or other purposes associated with the program planning and budgeting system, acquisition, or other DOE management control and direction processes. These independent evaluations must be based on knowledge of the actual project and related institutional matters. The Office of Program/Project Management will obtain this knowledge through reports from the project management and program organizations; conduct of field and Headquarters reviews with the program organization, the Departmental managing office, and principal contractors; and direct communication and discussion of project matters with the DOE managing and program offices.

Independent Cost Estimate. A documented cost estimate that has the express purpose of serving as an analytical tool to validate, cross-check, or analyze estimates developed by proponents of a project. An independent cost estimate also serves as a basis for verifying risk assessments. It is usually performed by an independent contractor.

Indirect Cost. A cost incurred by an organization for common or joint objectives and which cannot be identified specifically with a particular project or activity. See 10 CFR 600.

Inspection. The survey of a unit, facility or area to determine overall compliance with contract drawings and specifications. It may vary from inspection of detailed items to extensive testing of operating equipment (which must be provided for in the contract). It may also serve in making a determination of the adequacy of the design effort. It includes a preliminary inspection to fix the number of work items remaining to be completed (list of exceptions or "punch list"), and a final inspection to accept the completed construction.

Integrated Project Team. The Integrated Project Team (IPT) is approved by the appropriate SAE or AE and, at a minimum, consists of the program manager, the Federal project manager (once assigned), and a contracting officer (provided or approved by the director of procurement. The IPT is led by the Federal project manager and is responsible for managing the project. The IPT should consist of personnel having appropriate background and experience, in addition to contracting, fiscal, legal, and technical personnel. The makeup of the team would change/evolve with the project life cycle.

Invitation for Bid (IFB). Generally, this term is equivalent to request for proposal. However, in some application areas it may have a narrower or more specific meaning.

Lead Program Secretarial Officer (LPSO). The individual assigned line management responsibility and accountability for Headquarters and field operations and to which one or more multiprogram field offices directly report.

Level of Effort (LOE). Support-type activity (e.g., vendor or customer liaison) that does not readily lend itself to measurement of discrete accomplishment. It is generally characterized by a uniform rate of activity over a specific period of time.

Life-Cycle Cost (LCC). The sum total of the direct, indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of a major system over its anticipated useful life span. Where system or project planning anticipates use of existing sites or facilities, restoration, and refurbishment costs should be included.

Life-cycle Costing. The concept of including acquisition, operating, and disposal costs when evaluating various alternatives.

Line Item Projects. Projects that are specifically reviewed and approved by Congress. Projects with a total project cost greater than $5 million are categorized as line item projects.

Line Manager. (1) The manager of any group that actually makes a product or performs a service. (2) A functional manager.

Long Leadtime Procurement Items. Those items of equipment and/or construction materials that require an order date prior to the estimated physical construction start to assure availability at the time needed so as not to delay the construction performance.

Major System (MS) Projects. Any project or system of projects with a TPC of $400M or greater, or any other project so designated by the Deputy Secretary. Projects may be classified as MS either solely by the Deputy Secretary or by the Deputy Secretary in response to recommendations from the appropriate Under Secretary. OECM maintains and periodically publishes a list of MS projects.

Master Schedule. A summary-level schedule that identifies the major activities and key milestones. See also MILESTONE SCHEDULE.

Matrix Organization. Any organizational structure in which the project manager shares responsibility with the functional managers for assigning priorities and for directing the work of individuals assigned to the project.

Milestone Schedule. A summary-level schedule that identifies the major milestones. See also MASTER SCHEDULE.

Milestone. A significant event in the project, usually completion of a major deliverable. An important or critical event and/or activity that must occur in the project cycle in order to achieve the project objective(s).

Mission Need. A required capability within DOE's overall purpose, including cost and schedule considerations. When the mission analysis, or studies directed by appropriate executive or legislative authority, identify a deficiency in existing capabilities or an opportunity, this will be set forth as justification for purposes of system acquisition approvals, planning, programming, and budget formulation.

Missions.
a. Responsibilities assigned to the Department of Energy meeting national needs. Agency missions are defined by the Comptroller General of the United States in Budgeting Definitions, November 1975, as: "Those responsibilities for meeting national needs assigned to a specific agency. Agency missions are expressed in terms of the purpose to be served by the programs authorized to carry out functions or subfunctions which, by law, are the responsibility of that agency and its component organizations. (See Section 201 of the Budget and Accounting Act, 1921, as amended.)" b. Additionally, Section 601(i) of the Congressional Budget Act of 1974 (Public Law 93-344) requires that: "The Budget..." shall contain a presentation of budget authority, proposed outlays, and descriptive information in terms of: (1) a detailed structure of national needs that shall be used to reference

all agency missions and programs; (2) agency missions; and (3) basic programs. "To the extent practicable, each agency shall furnish information in support of its budget requests in accordance with its assigned missions in terms of Federal functions and subfunctions, including mission responsibilities of component organizations, and shall relate its programs to agency missions."

Mitigation. Taking steps to lessen risk by lowering the probability of a risk event's occurrence or reducing its effect should it occur.

Monitoring. The capture, analysis, and reporting of project performance, usually as compared to plan.

Monte Carlo Analysis. A schedule risk assessment technique that performs a project simulation many times in order to calculate a distribution of likely results.

Organizational Breakdown Structure (OBS). A depiction of the project organization arranged so as to relate work packages to organizational units.

Organizational Planning. Identifying, documenting, and assigning project roles, responsibilities, and reporting relationships.

Original Estimate. The first total estimated and total project cost that are shown: (1) in a project data sheet submitted to the Congress for line item projects; or (2) in a project data sheet submitted to OMB for contingency type projects; or (3) in the initial authorization for general plant, operating-funded, equipment-funded, or other contingency-type projects.

Original Schedule Dates. The start and finish dates of design, construction, procurement, and operation submitted in conjunction with the original estimate or in the first approved schedule.

Other Project. Any project with a TPC less than $400M and not designated as an MS project, including line item projects, general plant projects, and capital equipment, information technology, whether funded by capital or operating funds.

Overall Change Control. Coordinating changes across the entire project.

Parametric Estimating. An estimating technique that uses a statistical relationship between historical data and other variables (e.g., square footage in construction, lines of code in software development) to calculate an estimate.

Pareto Diagram. A histogram, ordered by frequency of occurrence, that shows how many results were generated by each identified cause.

Percent Complete (PC). An estimate, expressed as a percent, of the amount of work that has been completed on an activity or group of activities.

Performance Reporting. Collecting and disseminating information about project performance to help ensure project progress.

Performing Organization. The enterprise whose employees are most directly involved in doing the work of the project.

Phase. See PROJECT PHASE.

Physical Construction Start. For purposes of reporting construction progress, the date on which work at the site physically starts, including work on site preparation, temporary construction, and any earth moving. The start date of construction of permanent facilities should also be indicated.

Planned Finish Date (PF). See SCHEDULED FINISH DATE.

Planned Start Date (PS). See SCHEDULED START DATE.

Planning Estimates. Developed for each project at the time of project identification. Since these are developed prior to conceptual design, they are order of magnitude only and have the least amount of accuracy and lowest confidence level. Care should be exercised in these estimates to assure that the order of magnitude is correct, since a tendency exists to avoid changing this estimate, particularly upward, once established.

Plant Engineering and Design Funds. Appropriated by Congress at the request of the Department for the performance of preliminary and final design prior to authorization and appropriation of construction funds for a project. Plant engineering and design funds are limited to requests for projects that will receive high priority in a future-year budget submittal. Completed conceptual design is a prerequisite for allocation of plant engineering and design funds.

Preliminary Design. Continues the design effort utilizing the conceptual design and the project design criteria as a basis for project development. Title I design develops topographical and subsurface data and determines the requirements and criteria that will govern the definitive design. Tasks include preparation of preliminary planning and engineering studies, preliminary drawings and outline specifications, life-cycle cost analysis, preliminary cost estimates, and scheduling for project completion. Preliminary design provides identification of long-lead procurement items and analysis of risks associated with continued project development. For a detailed description of the services provided during preliminary design, see Department of Energy Acquisition Regulation (DEAR) 936.605c and 952.236.70.

Preliminary Design Estimates. Estimates prepared upon completion of preliminary design. Through use of plant engineering and design funds, preliminary design may be completed prior to inclusion of the project in the budget. If this should occur, the preliminary design estimate becomes synonymous with the budget estimate.

Preliminary Design Summary. An overview and record document of preliminary engineering and project management planning, reflecting completed preliminary design and usually prepared under architect-engineer services or by the operating contractor. Final design estimates are developed for each project by the designer as part of the preliminary design summary. The estimates, since they are based on the definitive design, are the most accurate and have the highest confidence level of any estimate.

Procurement Planning. Determining what to procure and when.

Product Data Requirement. A contract requirement that directs contractors to collect, organize, prepare, maintain, transmit, deliver, or retain information incident to the design, development, production, operation, preservation, maintenance, or repair of contract end items. Product data includes engineering drawings, product specifications and standards, part breakdown lists, catalog item physical qualities and characteristics, preprocurement data, test plans and reports, and other such data.

Program. An organized set of activities directed toward a common purpose or goal undertaken or proposed in support of an assigned mission area. It is characterized by a strategy for accomplishing a definite objective(s), that identifies the means of accomplishment, particularly in quantitative terms, with respect to manpower, materials, and facilities requirements. Programs usually include an element of ongoing activity and are typically made up of technology base activities, projects, and supporting operations.

Program Assessment. A determination of program condition based on a review of cost, schedule, technical status, and performance in relation to mission area assignments, program objectives, approved strategy, and milestones. Assessments are made by the responsible line program organization and outside the advocacy chain by the Office of Program/Project Management. In all cases, program assessments must be based on knowledge of the actual program status, performance, problems, and significant development in approval; review; and environment, safety, health, and quality assurance processes.

Program Management. Management responsibility and authority for specific programs will normally be delegated by the cognizant Program Secretarial Officer. The Headquarters' functions of program management includes planning and developing the overall program; establishing broad priorities; providing policy and broad program direction; preparing and defending the budget; establishing the technical performance, scope, cost, and schedule requirements for projects; controlling DOE Headquarters-level milestones; integrating all components of the program; providing public and private sector policy liaison; expediting Headquarters interface activities and followup actions; and retaining overall accountability for program success. The field function includes implementing these program activities, controlling field-level milestones, and providing major support to the Headquarters programming budgeting and processes.

Program Manager. An individual in an organization or activity who is responsible for: the management of a specific function or functions, budget formulation, and execution of the approved budget. The Program Manager receives an approved funding program from the Office of the Controller identifying program dollars available to accomplish the assigned function.

Program Objectives. A statement or set of statements defining the purposes and goals to be achieved during performance of a program to fulfill a DOE mission including the technical capabilities, cost, and schedule goals.

Program Office. The Headquarters organizational element responsible for managing a program.

Program Secretarial Officer (PSO). A senior outlay program official which includes the Assistant Secretaries for Conservation and Renewable Energy (CE), Defense Programs (DP), Fossil Energy (FE), Nuclear Energy (NE), Environmental Restoration and Waste Management (EM), and the Directors of Energy Research (ER), Civilian Radioactive Waste Management (RW), and New Production Reactors (NP).

Project. In general, a unique effort that supports a program mission, having defined start and end points, undertaken to create a product, facility, or system, and containing interdependent activities planned to meet a common objective or mission. A project is a basic building block in relation to a program that is individually planned, approved, and managed. A project is not constrained to any specific element of the budget structure (e.g., operating expense or plant and capital equipment). Construction, if required, is part of the total project. Authorized, and at least partially appropriated, projects will be divided into three categories: major system acquisitions, major projects, and other projects. Projects include planning and execution of construction, renovation, modification, environmental restoration, decontamination and decommissioning efforts, and large capital equipment or technology development activities. Tasks that do not include the above elements, such as basic research, grants, ordinary repairs, maintenance of facilities, and operations are not considered projects.

Project Charter. A document issued by senior management that provides the project manager with the authority to apply organizational resources to project activities.

Project Communications Management. A subset of project management that includes the processes required to ensure proper collection and dissemination of project information. It consists of communications planning, information distribution, performance reporting, and administrative closure.

Project Cost Management. A subset of project management that includes the processes required to ensure that the project is completed within the approved budget. It consists of resource planning, cost estimating, cost budgeting, and cost control.

Project Data Sheet. A generic term defining the document that contains summary project data and the justification required to include the entire project effort as a part of the Departmental budget. Specific instructions on the format and content of the project data sheet are contained in the annual budget call, and DOE O 5100.3, Field Budget Process.

Project Design Criteria. Those technical data and other project information developed during the project identification, conceptual design, and/or preliminary design phases. They define the project scope, construction features and requirements, and design parameters; applicable design codes, standards, and regulations; applicable health, safety, fire protection, safeguards, security, energy conservation, and quality assurance requirements; and other requirements. The project design criteria are normally consolidated into a document which provides the technical base for any further design performed after the criteria are developed.

Project Execution Plan. The Project Execution Plan is the primary agreement on project planning and objectives between the Headquarters Program Office and the Field, which establishes roles and responsibilities and defines how the project will be executed. The Project Execution Plan, once approved, becomes a significant tool for the project manager through the life of the project. The Headquarters or Field program manager and/or the Federal project manager initiates a Project

Execution Plan. Development of the preliminary Project Execution Plan can be started by the prime contractor or M&O/M&I at the same time as development of the Acquisition Plan or shortly after. The two plans should be synchronized. If the approved Acquisition Plan indicates that the M&O/M&I contractor has a role in the acquisition of the project as prime contractor/integrator, the M&O/M&I contractor may participate with DOE in development of the final Project Execution Plan.

Project Human Resource Management. A subset of project management that includes the processes required to make the most effective use of the people involved with the project. It consists of organizational planning, staff acquisition, and team development.

Project Integration Management. A subset of project management that includes the processes required to ensure that the various elements of the project are properly coordinated. It consists of project plan development, project plan execution, and overall change control.

Project Life Cycle. A collection of generally sequential project phases whose name and number are determined by the control needs of the organization or organizations involved in the project.

Project Management (PM). The application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project.

Project Management Body of Knowledge (PMBOK®). An inclusive term that describes the sum of knowledge within the profession of project management. As with other professions such as law, medicine, and accounting, the body of knowledge rests with the practitioners and academics who apply and advance it. The PMBOK® includes proven, traditional practices that are widely applied as well as innovative, and advanced practices that have seen more limited use.

Project Management. A management approach in which authority and responsibility for execution are vested in a single individual, at a level below the general manager, to provide focus on the planning, organizing, directing, and controlling of all activities within the project. In general terms, project management functions include assisting the program manager in preparing Headquarters documents and establishing key milestones and overall schedules. Other activities include developing and maintaining the project management plan; managing project resources; establishing and implementing management systems, including performance measurement systems; and approving and implementing changes to project baselines.

Project Manager (PM). An official who has been assigned responsibility for accomplishing a specifically designated unit of work effort or group of closely related efforts established to achieve stated or designated objectives, defined tasks, or other units of related effort on a schedule for performing the stated work funded as part of the project. The project manager is responsible for the planning, controlling, and reporting of the project.

Project Office. The organization responsible for administration of the project management system, maintenance of project files and documents, and staff support for officials throughout the project life cycle.

Project Phase. A collection of logically related project activities, usually culminating in the completion of a major deliverable.

Project Procurement Management. A subset of project management that includes the processes required to acquire goods and services from outside the performing organization. It consists of procurement planning, solicitation planning, solicitation, source selection, contract administration, and contract closeout.

Project Quality Management. A subset of project management that includes the processes required to ensure that the project will satisfy the needs for which it was undertaken. It consists of quality planning, quality assurance, and quality control.

Project Risk Management. A subset of project management that includes the processes concerned with identifying, analyzing, and responding to project risk. It consists of risk identification, risk quantification, risk response development, and risk response control.

Project Schedule. The planned dates for performing activities and the planned dates for meeting milestones.

Project Scope Management. A subset of project management that includes the processes required to ensure that the project includes all of the work required, and only the work required, to complete the project successfully. It consists of initiation, scope planning, scope definition, scope verification, and scope change control.

Project Summary Work Breakdown Structure. A summary work breakdown structure tailored by project management to the specific project with the addition of the elements unique to the project. Generally, the project summary work breakdown structure will identify project elements through the third level.

Projections. Estimates of budget authority, outlays, receipts, or other budget amounts that extend a minimum of 5 years beyond the current year. Projections generally are intended to indicate the budget implications of continuing current or currently proposed programs and legislation for an indefinite period of time. These include alternative program and policy strategies and ranges of possible budget amounts. Projects should be regarded neither as firm estimates of what actually will occur in future years nor as recommendations regarding future budget decisions.

Projectized Organization. Any organizational structure in which the project manager has full authority to assign priorities and to direct the work of individuals assigned to the project.

Quality Assurance (QA). (1) The process of evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards. (2) The organizational unit that is assigned responsibility for quality assurance. All the planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily in service. Quality assurance includes quality control, which comprises all those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements.

Quality Control (QC). (1) The process of monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance. (2) The organizational unit that is assigned responsibility for quality control.

Quality Planning. Identifying which quality standards are relevant to the project and determining how to satisfy them.

Real Property. Land and/or improvements including interests therein, except public domain land.

Remaining Duration (RDU). The time needed to complete an activity.

Request for Proposal (RFP). A type of bid document used to solicit proposals from prospective sellers of products or services. In some application areas it may have a narrower or more specific meaning.

Request for Quotation (RFQ). Generally, this term is equivalent to REQUEST FOR PROPOSAL. However, in some application areas it may have a narrower or more specific meaning.

Reserve. A provision in the project plan to mitigate cost and/or schedule risk. Often used with a modifier (e.g., management reserve, contingency reserve) to provide further detail on what types of risk are meant to be mitigated. The specific meaning of the modified term varies by application area.

Resource Leveling. Any form of network analysis in which scheduling decisions (start and finish dates) are driven by resource management concerns (e.g., limited resource availability or difficult-to-manage changes in resource levels).

Resource Planning. Determining what resources (people, equipment, materials) are needed in what quantities to perform project activities.

Resource-Limited Schedule. A project schedule whose start and finish dates reflect expected resource availability. The final project schedule should always be resource-limited.

Responsibility. The requirement or obligation that an individual is answerable for and accepts the consequences of their actions, activities, decisions, and obligations. In a project setting, responsibility is inseparable from authority and accountability.

Responsibility Assignment Matrix (RAM). A structure that relates the project organization structure to the work breakdown structure to help ensure that each element of the project's scope of work is assigned to a responsible individual.

Responsibility Chart. See RESPONSIBILITY ASSIGNMENT MATRIX.

Responsibility Matrix. See RESPONSIBILITY ASSIGNMENT MATRIX.

Retainage. A portion of a contract payment that is held until contract completion in order to ensure full performance of the contract terms.

Reviews. A determination of project or system acquisition conditions based on a review of project cost, schedule, technical status, and performance in relation to program objectives, approved requirements, and baseline project plans. Reviews are authorized by the SAE, AE, PSO responsible line managers, operations/field office manager or program managers. In all cases, reviews must be based on knowledge of the actual project status, performance, problems, and significant development in both the actual execution activities as well as required institutional approval, licensing, review, and environmental processes.

Risk Event. A discrete occurrence that may affect the project for better or worse.

Risk Identification. Determining which risk events are likely to affect the project.

Risk Quantification. Evaluating the probability of risk event occurrence and effect.

Risk Response Control. Responding to changes in risk over the course of the project.

Risk Response Development. Defining enhancement steps for opportunities and mitigation steps for threats.

Schedule Control. Controlling changes to the project schedule.

Schedule Development. Analyzing activity sequences, activity durations, and resource requirements to create the project schedule.

Schedule Variance (SV). (1) Any difference between the scheduled completion of an activity and the actual completion of that activity. (2) In earned value, BCWP less BCWS.

Scope Baseline. A configuration identification document or a set of such documents formally designated and approved at a specific time. (The time need not be the same for each document in the set.) Scope baselines, plus approved changes to those baselines, constitute the current configuration identification.

Scope Change. Any change to the project scope. A scope change almost always requires an adjustment to the project cost or schedule.

Scope Definition. Decomposing the major deliverables into smaller, more manageable components to provide better control.

Scope Planning. Developing a written scope statement that includes the project justification, major deliverables, and project objectives.

Scope Verification. Ensuring that all identified project deliverables have been completed satisfactorily.

Scope. In baseline management terminology, the term "scope" refers to those performance and design requirements, criteria, and characteristics derived from mission needs that provide the basis for project direction and execution. In budget terminology, the term "scope" refers to the Congressionally approved project parameter/tasks as defined in the Congressional Project Data Sheet. The sum of the products and services to be provided as a project.

S-Curve. Graphic display of cumulative costs, labor hours, or other quantities plotted against time. The name derives from the S-like shape of the curve (flatter at the beginning and end, steeper in the middle) produced on a project that starts slowly, accelerates, and then tails off.

Site. A geographic entity comprising land, buildings, and other facilities required to perform program objectives. Generally a site has, organizationally, all the required facilities management functions. That is, it is not a satellite of some other site.

Solicitation. Obtaining quotations, bids, offers, or proposals as appropriate.

Source Selection. Choosing from among potential contractors.

Staff Acquisition. Getting the human resources needed assigned to and working on the project.

Stakeholder. Individuals and organizations who are involved in or may be affected by project activities.

Statement of Work (SOW). A narrative description of products or services to be supplied under contract.

Subcontract. Any agreement or arrangement between a contractor and any person (in which the parties do not stand in the relationship of an employer and an employee): (a) For the furnishing of supplies or services or for the use of real or personal property, including lease arrangements, which, in total or in part, is necessary to the performance of any one or more contracts; or (b) Under which any portion of the contractor's obligation under any one or more contracts is performed, undertaken, or assumed.

System. A collection of interdependent equipment and procedures assembled and integrated to perform a well-defined purpose. It is an assembly of procedures, processes, methods, routines, or techniques united by some form of regulated interaction to form an organized whole.

Tailoring. A flexible approach to most aspects of the acquisition process, including program documentation, acquisition phases, and the timing, scope, and level of decision reviews. In a tailored approach to program oversight and review, project criteria are applied based on the program's size, risk, and complexity.

Team Development. Developing individual and group skills to enhance project performance.

Technical Direction. The monitoring or surveillance of the scientific, engineering, and other technical aspects of a work program, as distinguished from the administrative and business management aspects.

Technology Base. The equipment and facilities produced for, and the accumulated results and skills produced by, the conduct of basic research, applied research and technology development.

Technology. A demonstration by experiment of the technical feasibility of alternative inventive concepts. This category may concern itself with processes, components, equipment, subsystems, or an initial system prototype, and may encompass: experimental exploitation and refinement of a known phenomenon; demonstration of the acceptability of the technical and operational characteristics of one or more specific concepts; and preliminary system studies responsive to a particular problem including system analysis, tradeoff, preliminary cost/benefit studies, and planning and programming studies.

Total Estimated Costs (TEC) and Total Project Costs (TPC). Definitions for TEC and TPC are provided in DOE 5100.3, FIELD BUDGET PROCESS and 5700.2C, COST ESTIMATING, ANALYSIS AND STANDARDIZATION. The below listed definitions, extracted from these documents form the basis for development of standardized cost estimates. On occasion, there may be projects that cannot comply with these definitions and guidance. For these projects, variances must be requested by the project and approved by the Office of Program/Project Management prior to Key Decision No. 1 when establishing project baselines and requesting line item funding.

1. TEC. TEC includes the following estimated costs:

- Land, land rights, depletable resources, and improvements to land.
- Engineering, design, and inspection.
- Construction Management of main plant, balance of plant, other facilities, other structures and significant alterations, additions, and improvements to structures (excluding normal maintenance).
- Utilities—including water and sewage systems, heating, ventilation, and air conditioning, power systems, communication systems, and fire prevention systems.
- Quality Assurance.
- Preoperational construction changes shown to be required during integrated systems testing and hot-start testing.

- Safeguards and security systems.
- Project and construction management.
- Direct and indirect construction costs.
- Standard and special facilities.
- All equipment, furniture, and systems contained in main, balance of plant facilities, and administrative areas to render the facility useable.
- Computer systems, if dedicated to the project.
- Contingency and economic escalation.
- Decontamination and/or disposal cost of equipment and construction rubble when the purpose of the project is to replace existing facilities.

2. *TPC.* TPC includes all research and development (R&D), operating, plant, and capital equipment costs specifically associated with project construction up to the point of routine operations, which will include, but not be limited to:

- Total Estimated Costs.
- Pre-Preliminary activities, such as:
  - Conceptual Design Reports (CDR).
  - Preliminary Safety Analysis Report, if initiated prior to KD-1.
  - Preparation of Project Data Sheets, design criteria, National Environmental Policy Act (NEPA) documentation, and formulations of Quality Assurance Criteria.
- R&D necessary for fabrication, testing, and rework of prototype equipment.
- R&D (scale-up or demonstration plants of high-risk technology) required prior to start of construction.
- One-time costs related to testing, startup, operator training, and commissioning.
- Initial inventories and spare parts.
- Site suitability testing and evaluation.
- Quality Assurance related to site suitability and testing.
- Regulation compliance.
- Grant to state and local governments.
- Payments equal to taxes.
- Systems studies and selected systems engineering services.
- Institutional activities related to facility siting and external interactions.
- Decontamination and decommissioning costs.

- Economic escalation.
- Contingency (applicable to TPC).

Total Quality Management (TQM). A common approach to implementing a quality improvement program within an organization.

User. The entity that ultimately will operate or otherwise use the system being developed. When the project objective is to demonstrate to the private sector the utility or feasibility of a given system for commercial application, the identity of the ultimate user may not be known. In such case, only the most likely type of user (utility, constructor, energy supplier) may be identifiable.

Validation. The process of evaluating project planning, development, baselines and proposed funding prior to inclusion of new project or system acquisition in the DOE budget. It requires a review of project planning and conceptual development documentation, as well as discussion with the program or field element and principle contributing contractors to determine the source basis, procedures, and validity of proposed requirements, scope, cost schedule, funding, and so forth. Findings and recommendations resulting from the validation process will be provided for use in the annual budget formulation.

Value Engineering. The structured process of evaluating alternatives in a manner that yields the greatest cost savings, particularly when applied during the planning and design phases of a project. Value engineering should also be used during the construction phase of project.

Work Breakdown Structure (WBS). A deliverable-oriented grouping of project elements that organizes and defines the total scope of the project. Each descending level represents an increasingly detailed definition of a project component. Project components may be products or services.

Work Package. A deliverable at the lowest level of the work breakdown structure. A work package may be divided into activities.

Workaround. A response to a negative risk event. Distinguished from contingency plan in that a workaround is not planned in advance of the occurrence of the risk event.